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An In-depth Exploration of Artificial Intelligence's Role in Agricultural Automation: A Comprehensive Analysis

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Abstract

The need for food is rising due to the growing global population, which presents serious difficulties for conventional farming practices. Due to the increased usage of toxic pesticides by farmers, the fertility of the soil has been reduced, leaving barren land. Many automation technologies, including machine learning, deep learning, artificial intelligence, IoT, and wireless communications, are being investigated in agricultural practices to address these problems. Crop diseases, pesticide control, weed management, irrigation and water management, and storage management are all addressed by these technologies. The use of pesticides, managed irrigation, pollution prevention, and the effects of farming on the environment must all be addressed. Increasing agricultural output and improving soil fertility are two possible benefits of automation. This review study examines the state of automation in agriculture today and suggests a system for automated watering in botanical farms as well as for identifying flowers and leaves.

Introduction

The speed at which technology is developing in our more digital environment has increased the extent to which human intellect can be pushed as we work toward replacing biological brains with artificial ones. The field of Artificial Intelligence (AI) has emerged as a result of continuous investigation, wherein humans are trying to construct robots with intelligence. AI is a branch of computer science that tries to make machines more successful by helping them comprehend their surroundings. By utilizing ideas like CNN, ANN, machine learning, and deep learning, we may improve machine capabilities and propel the development of increasingly sophisticated technology.

AI is now present in many other areas, including manufacturing, banking, agriculture, education, healthcare, and security, to name just a few. The complex process of machine learning, a subdomain devoted to teaching machines to solve particular issues using historical and statistical data, is important to the application of artificial intelligence. Machine learning is currently being used for data analysis, voice and facial recognition, weather forecasting, and medical diagnostics.

It has been essential in the development of big data and data science. A mathematical approach to the creation of intelligent machines is machine learning.

New techniques and rational strategies have surfaced as AI develops, streamlining the problem-solving process. The ensuing discoveries have opened up new avenues for research and greatly enhanced the fields of artificial intelligence and machine learning.

- Fuzzy logic
- Artificial neural networks (ANN)
- Neuro-fuzzy logic
- Expert systems

Working of ANN

There are numerous arrangements for individual neurons in neural networks. This configuration allows information to be processed in a flexible, dynamic, and self-organizing manner in the human brain. Neural networks form biologically using microscopic components in a three-dimensional environment, enabling almost endless connections. On the other hand, artificial networks built using existing technology can only be two-dimensional structures with a finite number of link layers. The kinds and sizes of artificial neural networks that can be created on silicon are limited by this physical constraint.

(Ms. Sonali. B. Maind, Ms. Priyanka Wankar., 2014).

- Input layer
- Hidden (middle) layer
- Output layer (Fig. 1)

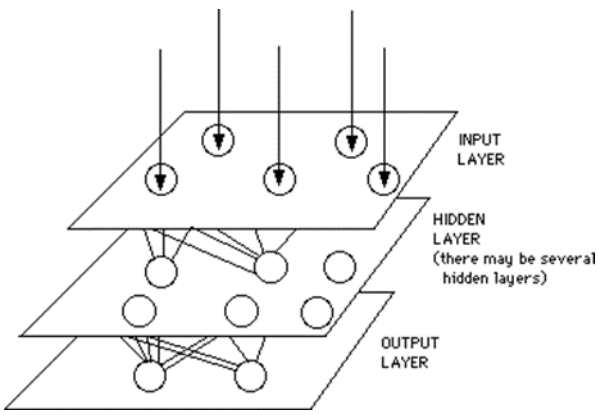

Figure 1: Artificial neural network layers (Ms. Sonali. B. Maind, Ms. Priyanka Wankar., 2014)

Embedded systems architecture

Architecture evaluation is becoming a crucial component of software and system design. Its impact on the program or system during its lifetime and the entire design process is evident in the early stages of design when architectural development takes place. Making architectural decisions requires a lot of work in order to guarantee high-quality designs. Just defining the architecture with accuracy and attention on its goals is merely the first step in the proper direction. Assessing architectures to ensure that design objectives are met is another crucial component. (Bastian Florentz and Michaela Huhn, 2006).

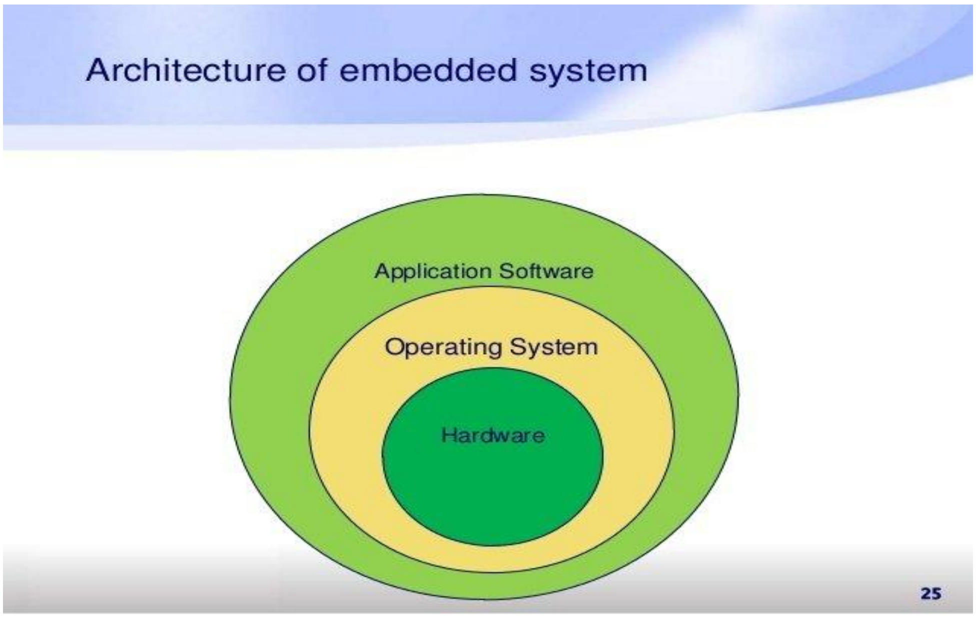

Figure 2: Embedded Systems Architecture: (M.Nasim Khaliqhey, 2017)

Literature survey

Artificial intelligence has developed sustainably during the past 50 years since it is widely used in all fields and has a robust application. Agriculture is one such area. Agriculture is not a smoothly operating industry and faces several problems on a daily basis. During the process of planting seeds and harvesting crops, farmers may encounter the following issues:

- Infestations of crop diseases
- Inadequate handling of storage.
- Control of pesticides
- Control of weeds
- Absence of drainage and irrigation infrastructure.

Machine learning and artificial intelligence have permeated every single category listed above. Bannerjee et al. (2018) provided a succinct summary of key AI techniques and divided advances in AI into categories. In this industry, computers and technology began to become more prevalent in 1983. From databases to decision-making processes, a plethora of ideas and strategies for improving agriculture have been put forth since then. After sorting through all the processes, AI-based solutions have emerged as the most practical and dependable. The AI-based approach provides a specific answer to a specific defined complex problem without generalizing the problem. The review of the literature includes significant developments in the field of agriculture from the early 1980s to 2018. More than fifty technological advancements in the agricultural subdomain are covered in this publication. The use of expert systems and artificial neural networks to address the aforementioned issues is covered first, followed by machine learning and fuzzy logic systems. Finally, it discusses IOT and automation in agriculture.

Artificial neural networks in agriculture

Because artificial neural networks offer several benefits over traditional systems, the agriculture sector has used them extensively. Neural networks' primary advantage is its capacity for forecasting and prediction based on parallel thinking. Neural networks may be learned in place of being fully programmed. ANN was utilized by Gliever and Slaughter (2001) to distinguish weeds from crops.

A system of experts Prakash et al. (2013) created PRITHVI in Rajasthan, India, using fuzzy logic. The technology was specifically created for the soybean crop. The information foundation for this system was produced by published literature, agricultural officers, and specialists in soybean crops. Fuzzy logic was taken into account while analyzing the entire system and providing the farmer with professional advice. PRITHVI has been split up into five sections. The primary objective behind creating this expert system was to assist local farmers in raising their soybean yield. MATLAB was the user interface module utilized by the system.

Researchers Ravichandran and Koteshwari tried a strategy that suggests using ANN algorithms for crop prediction on smartphones in 2016. The method was successful. A model for prediction was created. The system's prediction model consisted of three layers, as previously indicated (Ravichandran and Koteshwari, 2016). The number of hidden layers in the model determined its efficiency. First and foremost, in order to determine the most advantageous configuration, the ANN model was constructed and trained using a variety of techniques, including Rprop, Silva and Almeida's algorithms, and Delta-bar-delta. A process of trial and error was used to determine the quantity of hidden layers. Since the number of hidden layers affects the prediction system's accuracy, there should be a precise method for carefully examining the selection of certain hidden layers. The study found that the more hidden layers an artificial neural network (ANN) model had, the more accurate the predictions were. The system was designed on the APK platform since its intended use was to make it convenient for farmers. The algorithm was created using Matlab and the ANN toolbox, and the source code was written in Eclipse using Java scripts in the background. After that, the entire file was extracted for use with cellphones on the Android operating system. In addition to recommending the crop to the farmer, the system also provides the added benefit of advising on fertilizer use, should the farmer choose to employ a different crop. In 2016, Rafael Chandran and Koteshwari (Figure 3)

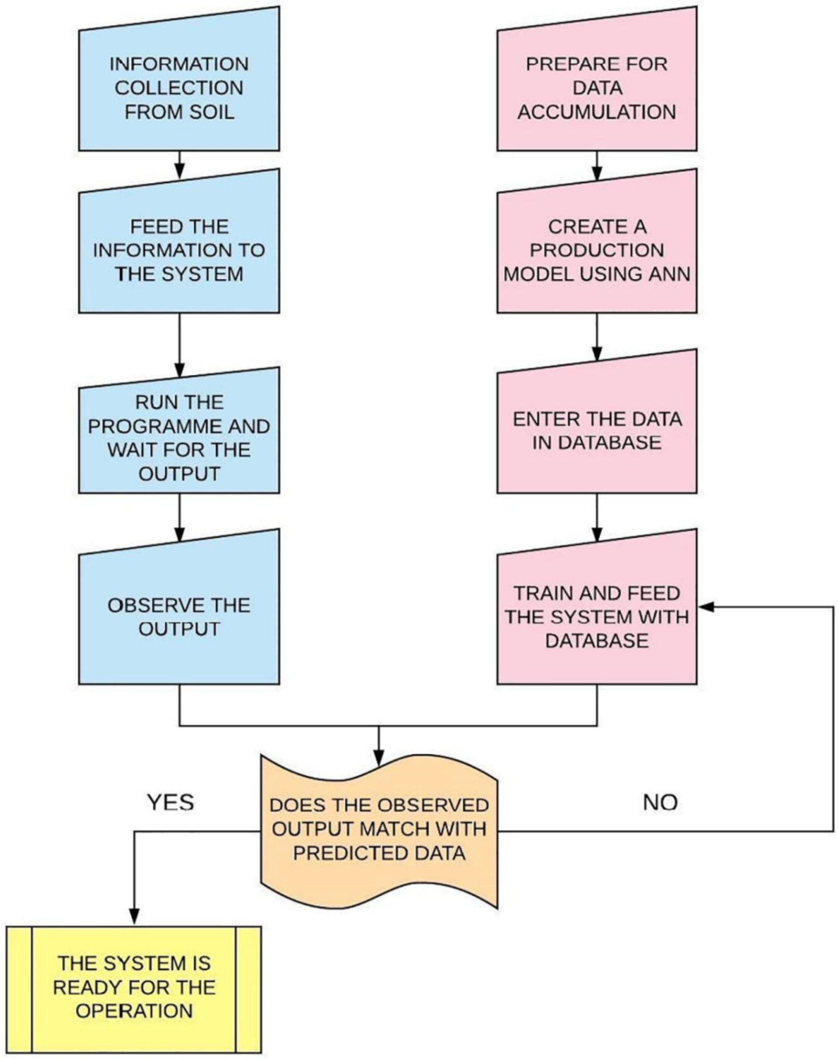

Figure 3: Flowchart of ANN-based crop predictor using smartphones

Automation and wireless system networks in agriculture

Any industry has to change over time anyhow. The agricultural industry has to adjust to the innovations and discoveries in the realm of automation. Yong et al. (2018) introduced the field of embedded intelligence (EI), which is a developing field of study. Smart farming, smart greenhouses, smart irrigation, and smart crop management are all examples of embedded intelligence in the agriculture industry. Because so many other areas of the economy depend on agriculture, a country's ability to expand depends on its ability to integrate these rapidly developing technology into its agricultural sector. Additionally, the authors of this work presented the Technology Roadmap (TRM), which allays concerns about the aforementioned agricultural domains (smart irrigation, smart farming, etc.).

A method that anticipated grape illness in advance was created by researchers Patil and Thorat (2016), taking into account the socio-economic importance of agriculture in India. The entire vineyard suffered greatly as a result of the grape plant's oddity remaining undetected until it became diseased. The system used a variety of sensors throughout the vineyard, including humidity, leaf wetness, and temperature sensors. The database in the ZigBee server, which is connected to the sensors, receives the data that these sensors perceive. Wireless System Network (WSN) deployment in any field must meet specific requirements, and the Zigbee Alliance has created open worldwide standards known as ZIGBEE. As said, there are four levels that comply with Zigbee: the physical layer, the medium access control layer, the network layer, and the application layer. In a wireless network, each of the three devices—a Zigbee coordinator (ZC), a Zigbee router (ZR), and a Zigbee end device (ZED)—has a distinct purpose. In agriculture, Zigbee's end-to-end method is covered by Kalaivani et al. (2011). The data will be kept on the server. When the server is put into service, it has a hidden Markov model algorithm. This algorithm's purpose is to train the sensors' typical data and notify farmers by SMS of any anomalies in temperature, humidity, or leaf wetness that may lead to grape disease. In order to make an intelligent diagnosis of grape disease, machine learning is integrated into the system in advance. This approach has the added benefit of recommending pesticides to farmers and relieving human labor-intensive disease identification tasks. Thorat and Patil, 2016). Whereas the development of paddy crops was tracked using a similar machine learning technique. The purpose of developing this technique was to boost the productivity and output of paddy crops. It also shown to be reliable and reasonably priced. (Kait and others, 2007)

Proposed idea

The agriculture industry urgently needs automation, and there are several practical ways to do so. The first area where automation is required for the best use of water is irrigation. A soil moisture sensor assists in measuring the soil's moisture content and begins watering the farm when the value falls below the farmer's designated threshold. The Internet of Things and embedded systems work together to create a small system that tracks the farm's water level without requiring human intervention.

We may use a wide range of approaches, including machine learning, artificial intelligence, deep learning, neural networks, and fuzzy logic, to automate processes. The goal is to minimize human effort and involvement by utilizing any of these expanded techniques. While each of these approaches has pros and cons of its own, how they are used sets them apart from one another. There is very little research being done on deep learning techniques that classify flowers or plants based on their analysis of visual datasets from previous data feeds. The principles of deep learning in agriculture and the initiatives to implement deep learning techniques in different agricultural sectors are discussed by Kamilaris and Prenafeta-Boldú (2018). Deep learning applications are necessary in this discipline since they have a significant influence on contemporary approaches and expand machine learning by giving models greater depth. The raw data process is the primary component of deep learning, which improves categorization and accuracy. The major applications of deep learning are in plant recognition, fruit counting, and crop yield prediction. While some strategies employ text data to train the model, others require large datasets of pictures. Deep learning requires the use of data sources, pre-processing, variation, and augmentation techniques in order to train the model. Deep learning in agriculture offers a wide range of potential applications and a potential to expand the industry. In his research, Ferentinos (2018) employed convolution neural network models and deep learning in the system, training the model with a variety of photos of both healthy and sick plants. Due to the intricacy of diagnosing plant diseases, many agronomists are unable to identify a particular disease. Up to 99.53% accuracy and precise identification are provided by the model.

The goal is to train the model so that it can recognize flowers or plants when it receives more images in the future. Since VGG16 is the most straightforward model among all the other convolutional networks, it is utilized to train the model. The simplicity of this network lies in its use of only three 3×3 convolutional layers piled deeper and deeper on top of one another. By using max pooling, volume size reduction is managed. After that comes two fully-connected layers, each with 4096 nodes, and a softmax classifier. The number of weight layers in the network is represented by the number "16" in VGG16. The network designs VGG, ResNet, Inception, and Xception are included in the Python Keras package. A sizable picture dataset featuring a variety of flowers and plants is utilized to train the model and assess its accuracy. When any random image is entered into the algorithm, the model then correctly guesses the plant or flower.

In the agricultural industry, this method is essential as each plant has specific environmental requirements. A consistent supply of water at regular intervals and the presence of favorable atmospheric gases facilitate the optimal growth of plants. Farmers and botanists can grow plants more easily thanks to deep learning categorization, as they can identify the plant and its ideal growing parameters, then give the right habitat and irrigation.

Future scope

Younger farmers will be more interested in investing in technology than more experienced farmers. New technologies must be implemented gradually over time. The agricultural industry is gradually transitioning to precision farming, whereby plant-by-plant management will be carried out. The plant or flower type is identified using deep learning and other advanced techniques, which will assist farmers in creating an environment that will support the plant's sustainable growth. The range of goods and manufacturing methods will rise as the development of increasingly customized fruits and plants continues to expand. Artificial intelligence techniques are expanding quickly, and they may be utilized to employ CNN, RNN, or any other computational network to identify plant diseases or undesired weeds on farms. A specific habitat may be given to the plants by greenhouse farming, however this is not feasible without human involvement. Here, wireless technology and the Internet of Things come into play. By utilizing the newest sensors and communication protocols, we can integrate weather monitoring and control on the farm without the need for human presence. Robots that are trained to operate around the clock to expedite the harvesting process can also be used for fruit and crop harvesting. Robots have several uses in agriculture, including planting and sowing, watering and fertilizing, spraying and weeding crops, harvesting, and shepherding. In many circumstances, it would take 25 to 30 personnel to finish the same task. Drones and thermal cameras can also be used to execute thermal imaging. Drones are used to monitor farms and provide farmers with continuous, real-time data on the field. This allows farmers to identify areas of the field with lower water quantities and only begin irrigation in those specific areas. This will keep the field from flooding or becoming too dry, and the crops will always have an adequate supply of water. Many different integrated approaches can be used to provide a viable environment and increased growth.

Conclusion

The technique of minimizing human interventions in agriculture is heavily dependent on monitoring. The need for food is rising steadily, and it will be difficult to meet this need without using contemporary agricultural techniques. The main priority is agriculture monitoring as it lowers labor costs and boosts output. Artificial intelligence has been used to choose crops and assist farmers in choosing fertilizers. The machines talk among themselves to determine which crop is ready for harvesting and which fertilizers would encourage the highest rate of development. This is done with the assistance of the database that the user has collected and sent to the system. Deep learning has many applications, and industrial use of it has advanced significantly. Applying deep learning enhances machine learning and gives it a deeper understanding. Better harvests and appropriate field management may be guaranteed for farmers through a number of important techniques. Food is a basic human requirement, therefore in the end, this contributes to the nation's total growth. IOT highlighted how important it is to provide data monitoring in real time. The major use of IOT is in intelligent irrigation systems. Since the water problem may be resolved with the application of automation and technological advancements, it is imperative to make efficient use of the freshwater resources that are now accessible. In today's world, traditional agricultural approaches hardly make a dent. Agriculture automation develops as a result of several flaws in this system and the grave necessity to safeguard agricultural land. The goal presented in this article is to create a system that automates conventional agricultural techniques through the use of sensors, IOT, and machine learning.

References

Jha.K., Doshi, A., Patel, C., Shah, M. (2019). A comprehensive review on automation in agriculture using artificial intelligence. Artificial Intelligence in Agricultur. Volume 2, Pages 1-12

G. Bannerjee, U. Sarkar, S. Das, I. Ghosh. (2018).Artificial Intelligence in Agriculture: A Literature Survey. International Journal of Scientific Research in Computer Science Applications and Management Studies., 7 (3) , pp. 1-6

Ms. Sonali. B. Maind, Ms. Priyanka Wankar(2014). Research Paper on Basic of Artificial Neural Network. International Journal on Recent and Innovation Trends in Computing and Communication Volume: 2 Issue: 1

Bannerjee et al. (2018) Artificial Intelligence in Agriculture: A Literature Survey. International Journal of Scientific Research in Computer Science Applications and Management Studies, Volume 7, Issue 3

Gliever, C., Slaughter, D.C., (2001). Crop verses weed recognition with artificial neural net-works. ASAE paper. 01-3104 (2001), 1-12.

Prakash, C., Rathor, A.S., Thakur, G.S.M., (2013). Fuzzy Based Agriculture Expert System for Soyabean. pp. 1-13.

Ravichandran, G., Koteshwari, R.S., (2016). Agricultural crop predictor and advisor using ANN for smartphones. IEEE 1-6.

Yong, W., Shuaishuai, L., Li, L., Minzan, L., Arvanitis, K.G., Georgieva, C., Sigrimis, N., (2018). Smart sensors from ground to cloud and web intelligence. IFAC-Papers OnLine 51 (17), 31-38.

Banerjee, G., Sarkar, U., Ghosh, I., (2017). A radial basis function network based classifier for detection of selected tea pests. International Journal of Advanced Research in Com- puter Science and Software Engineering. 7 (5), 665-669.

Patil, S.S., Thorat, S.A., (2016). Early detection of grapes diseases using machine learning and IoT. Second International Conference on Cognitive Computing and Information Processing (CCIP), IEEE 1-5

Kalaivani, T., Allirani, A., Priya, P., (2011). A survey on Zigbee based wireless sensor networks in agriculture. IEEE 85-89.