Digital Farming in the 21st Century: A Technical perspective

Ashu Kumar
B.E student, Global Academy of Technology, Bangalore, India. Email: itsmeashusingh21@gmail.com

Abhishek Singh
B.E student, Global Academy of Technology, Bangalore, India. Email: 0618singhabhishek@gmail.com

Snigdha Sen
Assistant Professor, Global Academy of Technology, Bangalore, India. Email: snigdha.sen@gat.ac.in

Introduction

As India is mostly an agriculture-based country, recent development and proliferation of advanced technologies is taking India to a greater height in agriculture sector. Old days are gone where farmers had to put lot of effort in their daily activities of crop production and selling. In recent days, we can hardly name few areas where Machine learning (ML), blockchain and IOT are not being used. Indeed, these technologies are omnipresent. Machine learning algorithms can analyse data collected from sensors and drones on the farm, such as weather patterns, soil moisture, and crop health, to help farmers make more informed decisions about irrigation, fertilization, and pest control. It can also be used to analyse data on foodborne illness outbreaks and predict potential risks. ML algorithms can analyse data on weather patterns and crop yields to help insurance companies better predict risks and set premiums.

When it comes to security aspects, Blockchain can be used to securely store this data, ensuring its integrity and preventing tampering. It can also be used to track the journey of crops from farm to consumer, allowing for greater transparency and traceability. After the outbreak and prediction of potential risks is being made by the ML models, Blockchain tracks the source of contaminated food, allowing for more targeted recalls and reducing the risk of widespread outbreaks. It can store different types of data provided to it, ensuring its integrity and preventing fraud.

Therefore, the integration of machine learning and blockchain can help farmers make more informed decisions, reduce waste and inefficiency in the supply chain, and improve food safety and sustainability. IoT sensors can collect data on different factors including soil moisture, temperature, road condition, financial transaction, etc. Which helps in passing these several types of data to the ML model to solve real-life problems.

Challenges in the modern agriculture industry

The following is a list of the difficulties that the farming sector and agriculture face:

1. A shortage of labourers and resources
2. Environmental issues and climate change
3. Need for significant manual intervention
4. Insufficient monitoring
5. Challenges in analysing the large-scale unstructured data

IoT in smart agriculture

The Internet of Things (IoT) is a network of real-world things such as machinery, cars, buildings, and other physical objects that are equipped with sensors, software, and network connectivity. IoT sensors can be used in agriculture to track environmental variables including humidity, temperature, and soil moisture.

Farmers may get real-time data and use it to optimise crop output by deploying IoT devices. For instance, farmers can immediately water the crops if the data indicates that the soil is too dry, lowering the chance of crop loss due to drought.

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1. **Soil monitoring:** IoT sensors may be used to track soil moisture, pH, and nutrient levels, which enables farmers to make better decisions about irrigation and fertilisation.

   IoT sensors can be buried in the ground to track important soil characteristics like moisture content and nutrient levels. Farmers can receive real-time information about the condition of their soil by connecting these sensors to a network that gathers and analyses the data. Using this knowledge, farmers may modify their fertilisation and irrigation methods to make sure that crops get the ideal balance of nutrients and water. This not only results in better crops but also has the potential to reduce water and fertiliser waste, improving the sustainability and profitability of farming.

2. **Weather monitoring:** Farmers can use IoT devices to gather information about weather patterns to assist them plan their planting, harvesting, and other farming activities.

   The weather has a significant impact on agricultural productivity. Real-time data regarding temperature, humidity, wind speed, rainfall, and other weather variables can be gathered with IoT devices. Following that, farmers can utilise this information to make knowledgeable choices regarding planting, harvesting, and other farming operations. Farmers can utilise weather information, for instance, to choose the optimum time to grow crops or the best time to use pesticides or fertilisers. Farmers who have access to the most recent weather data can make better decisions that will increase the quality of their crops while lowering the risks connected with weather-related problems like drought and flooding.

1. Drone-based uses:

Technology has improved significantly and more quickly during the past few years. The use of drones in farming is a great example of this progression. Drones are being used in the agriculture sector to advance a variety of farming practises.

Both aerial and ground-based drones are used in agriculture for a number of functions, such as field analysis, irrigation, planting, pesticide application, crop health evaluations, and monitoring. These drones capture multispectral, thermal, and visual imagery while in the air.

Many applications for drones in agriculture exist, including soil analysis, crop spraying, and crop monitoring. The following are some benefits and drawbacks of employing drones in agriculture:

Pros:

1. **Better Crop Monitoring:** Drones can be used to monitor crop health, spot stressed areas, and even spot early symptoms of disease or insect infestation. These drones may be fitted with cameras or other sensors. This can assist farmers in making timely corrections and minimising crop losses.

2. **Precision Agriculture:** Drones can be used to build comprehensive maps of farmland that include details about the crop yield, moisture content, and soil quality. This can save waste and help farmers make the most use of resources like water and fertiliser.

3. **Effective Crop Spraying:** Drones carrying sprayers can spray crops with fertilisers, insecticides, or herbicides. Traditional methods cannot accomplish this as well as drones, which can precisely target the areas that require treatment and hence reduce the overall amount of chemicals required.

4. **Labour Savings:** By using drones for agricultural monitoring and spraying, farmers can manage their crops more cheaply and easily by eliminating the need for physical labour.

In general, farmers may gain a lot from using drones in agriculture, including better crop monitoring, precision farming, and labour savings. The limited battery life, cost, technical expertise, and regulatory compliance are a few difficulties to take into account.

2. Smart Irrigation system

A form of irrigation system called "smart irrigation" employs technology to assist farmers and gardeners get the most out of their water resources. Usually, sensors and meteorological information are used to calculate when and how much water is required, and the system then automatically supplies the water to the plants.

Pros:

1. **Water Conservation:** By providing the proper quantity of water to plants and preventing over- or under-watering, smart irrigation systems may help minimise water use. Water is conserved, and water costs are decreased.
2. **Economical:** Smart irrigation systems are more cost-effective than conventional irrigation systems, which ultimately saves time and money.
3. **Convenience:** With a smart irrigation system, you can forget to switch off the water or don't have to water plants by hand.
4. **Improved Plant Growth:** By ensuring that plants receive the proper amount of water, smart irrigation systems can help produce healthier, more vibrant plants.

3. Tank level monitoring

IOT helps to remotely monitor the level of the water tank and configure the alerts when the specific level has been reached.

Machine learning in smart agriculture

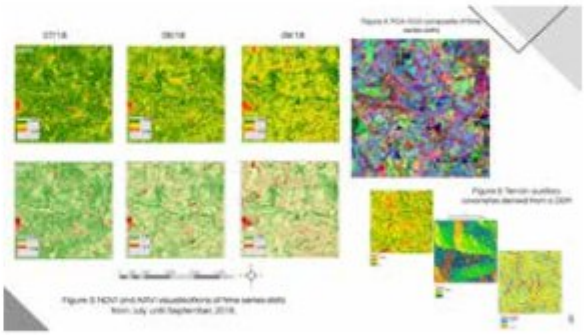
A form of artificial intelligence known as machine learning (ML) enables computers to learn and develop without having to be explicitly programmed. ML can be used in agriculture to analyse data gathered by IoT sensors and forecast crop growth, production, and quality.

Source: GAO. | GAO-19-136SP

For instance, ML algorithms can examine data on temperature, humidity, and soil moisture to determine when to sow crops. Farmers can use machine learning (ML) algorithms to make data-driven decisions that can increase crop yields and decrease waste.

1. Crop Yield Prediction

By examining a lot of data on weather patterns, soil quality, and previous crop yields, machine learning can aid in the forecast of agricultural output. Machine learning can accurately estimate crop yields for a specific season by finding patterns and connections between these factors using algorithms and statistical models.The best crops to plant can be determined using historical data and the present weather, and machine learning can also be used to anticipate new crops that might do well in a specific location based on historical data.



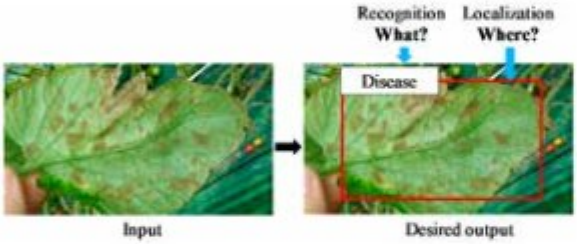
By suggesting the best times and amounts for these inputs, machine learning may also assist farmers in optimising their use of resources like water, fertiliser, and pesticides. This helps minimise waste and increases crop growth and output.

2. Pests and Disease Detection:

- **Picture Recognition:** Machine learning algorithms can identify diseases and pests in photos taken by field cameras or drones. Machine

learning can identify the traits that are indicative of a specific pest or illness by examining massive databases of photos, and it can then classify new images in that manner.

- **Sensor Data Analysis:** Sensors in the field, such as soil moisture sensors, temperature sensors, and others, can provide useful information on the circumstances that encourage pest and disease outbreaks. This data can be analysed by machine learning to provide early outbreak warning.
- **Precision Agriculture:** By evaluating data on the location and severity of outbreaks, machine learning can help farmers target their pest and disease management strategies more precisely. This can lower pesticide consumption, save money, and have a smaller negative impact on the environment.



As we can see in the above image how by using image processing and prediction models it's being derived from a patch of leave that whether there's a disease or not.

3. Precision Farming:

By utilising data analysis to enhance agricultural techniques and maximise crop yields, machine learning aids in precision farming. The following are some applications for machine learning:

1. **Predictive analysis:** Machine learning algorithms can evaluate data from weather sensors, sensors for measuring soil moisture, satellite imaging, and other sources to forecast weather patterns, precipitation, and the best times for planting and harvesting.
2. **Soil analysis:** Machine learning may assist in analysing soil data to identify the best crops to produce, potential needs for soil amendments, and the amount of fertiliser to use.
3. **Crop health monitoring:** Algorithms that use machine learning can examine photos of plants to find illnesses, pests, and other problems that may affect crop health. Farmers are now able to act promptly to avoid crop losses.

4. Livestock Management:

ML algorithms can assist in enhancing livestock management in a number of ways, such as:

1. **Predictive analytics:** ML algorithms are able to assess data from a variety of sources, such as animal behaviour, weather, feed intake, and health records, to forecast possible issues and stop them from getting worse. They can signal symptoms of illness such as an animal's decreased appetite or agitation.

2. **Disease detection and prevention:** Machine learning algorithms can assist in identifying early symptoms of illness, tracking disease outbreaks, and recommending preventive actions to stop the spread of the disease by analysing data from electronic health records.
3. **Feed and nutrition optimisation:** Machine learning algorithms can assist in optimising the types and amounts of feed given to certain animals or groups of animals based on their nutritional requirements, weight increase. This is done by studying animal behaviour data.
4. **Breeding and herd management:** Using genetics, prior performance, and other characteristics, machine learning can assist breeders in selecting the best animals to breed. Also, it can assist in herd management by creating individualised care plans for individual animals and monitoring their development to make sure they're achieving their performance targets.

In general, machine learning helps generate insights that can enhance the health and productivity of livestock, which can boost farm profitability and contribute to global food security.

Blockchain in smart agriculture

Blockchain is a distributed ledger technology that makes

it possible to store data in a safe and unchangeable way. Blockchain technology can be utilised in agriculture to establish a safe and transparent supply chain.

Blockchain can be used, for instance, to trace the origin of food goods, guaranteeing that they are produced in an ethically and sustainably. In addition to giving farmers a fair price for their goods, this can assist build consumer confidence in the food supply chain.

1. Digital identity:

A crop's digital identity is created by capturing and archiving information about the crop on the blockchain. Information about the type of seed that was used, the date of planting, the application of fertilisers and pesticides, and the date of harvest can all be found in this data. Farmers and other stakeholders may monitor a crop's development and make sure it satisfies consumer and regulatory expectations by giving each crop a digital identity.

Benefits:

1. Stakeholders can quickly access and verify information on the movement of the crop from the farm to the consumer by storing data on the blockchain. By doing so, you can increase stakeholder trust and make sure the supply chain is running smoothly.
2. It may contribute to greater sustainability. Farmers can choose better crop management strategies by keeping track of facts like the use of pesticides and fertilisers.

2. To predict actual prize of crop/land of the farmer.

A transparent and secure platform for recording the ownership and transaction history of real estate properties might be offered via blockchain technology. Yet estimating the cost of land that will be sold is a challenging task that calls for a combination of market research, data science, and knowledge of the real estate sector.

Here are some potential uses of blockchain to forecast the cost of land that will be sold:

Smart Contracts: Self-executing contracts, or "smart contracts," are agreements that automatically uphold the terms of a contract between two parties. Blockchain can lower the possibility of human mistake and offer a more secure and efficient transaction process by using smart contracts to automate the purchasing and selling of land.

Blockchain-based decentralised applications (DApps) can offer a platform for the research of the real estate market.

Tokenization: Real estate assets can be tokenized using blockchain technology, enabling investors to buy a portion of an asset. This could improve the real estate market's liquidity and possibly offer more precise price data based on the worth of individual tokens.

Land Registry:

A safe and impenetrable land registration can be built using blockchain technology. This would lessen the possibility of fraud and eliminate the necessity for manual record-keeping. Land registration data might be safely and transparently tracked changes in ownership, mortgages, and other transactions by using blockchain technology to record the data.

3. To provide land for lease:(IN OFF SEASON)

A safe and transparent platform for renting out land to farmers can be made using blockchain technology. The following are some applications for blockchain in this context:

Immutable Records: Blockchain technology enables the production of immutable records, which means that a transaction cannot be changed after it has been recorded on the blockchain. By doing this, the lease agreement is made impenetrable and offers a high level of protection to both the landowner and the farmer.

Decentralized Platform: Farmers can access accessible land directly and without middlemen by using a decentralised platform. The platform can be made to enable peer-to-peer leasing between farmers and landowners, which lowers transaction costs.

Verification: The identity of the farmer and landowner can be confirmed via blockchain. This guarantees that both the farmer and the landowner are legitimate owners of the property.

Blockchain can make payments between the farmer and the landowner secure and transparent. This can be accomplished via cryptocurrencies or other electronic payment methods, which eliminates the need for currency transactions and offers a safe and effective payment system.

Pros of smart agriculture:

1. **Increased efficiency:** Smart agriculture can help farmers optimize their use of resources such as water, fertilizer, and energy, resulting in increased efficiency and reduced costs.

2. **Higher yields:** By monitoring crop growth and environmental factors, smart agriculture can help farmers improve crop yields and quality.
3. **Improved sustainability:** Smart agriculture can help reduce the environmental impact of farming by reducing water and fertilizer use, minimizing the use of pesticides and herbicides, and reducing greenhouse gas emissions.

Conclusion:

In conclusion, incorporating IoT, ML, and blockchain in smart agriculture can offer a number of advantages to farmers, consumers, and other industry players. ML algorithms may analyse this data to produce insights and make data-driven decisions regarding irrigation, fertilisation, and pest control by employing IoT sensors to gather information about crop status, weather, and other variables. A tamper-proof and transparent log of all transactions can be created by storing this data on a blockchain, enhancing supply chain traceability and transparency. The supply chain can be automated through the use of smart contracts, and stakeholders can access data through a user interface to collaborate and make decisions more effectively. In general, smart agriculture that incorporates IoT, ML, and blockchain can increase production, sustainability, and efficiency in the agricultural sector.

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About the Authors

Ashu kumar is pursuing bachelor degree in Computer Science Engineering at Global Academy of Technology, Bengaluru. Being passionate about innovative things, He aims at delivering effective and useful content for the betterment of mankind. His area of interest lies in defence and military and cyber security.

Abhishek Singh is pursuing Bachelor Degree in Artificial Intelligence and Data Science at Global Academy of Technology, Bengaluru. Experienced in Research and Back-end Development as a research intern at IIIT, Allahabad, and a back-end developer in a start-up company. He strives to translate business challenges into efficient machine learning solutions.

Snigdha Sen is currently working as an Assistant Professor in Department of Computer Science and Engineering, Global Academy of Technology, Bangalore, India. She is having around 10 years of teaching experience. She is pursuing PhD in Machine Learning from IIIT, Allahabad. She completed her Masters in Information Technology from Jadavpur University, Kolkata. Her area of interest lies in Machine Learning, Bigdata, Internet of Things and Cloud Computing.