Huda Lafta Majeed
Hussein Najm Abd Ali

Artificial Intelligence and the Internet of Things

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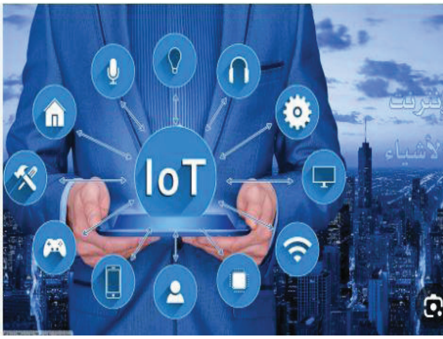

Artificial Intelligence and the Internet of Things

By
Dr. Huda Lafta Majeed
Dr. Hussein Najm Abd Ali
(2023)

Artificial Intelligence and the Internet of Things

Dr. Huda Lafta Majeed

Field Crop Department, College of Agriculture,

Wasit University, Iraq.

Email: hulafta@uowasit.edu.iq

Mobile: (+964)7702435901

Dr. Hussein Najm Abd Ali

Computer Engineering, Information Systems Technology

College of Education for Pure Science, Wasit University, Iraq

Email: Hanjim@uowasit.edu.iq

Mobile: (+964)7724988998

Bachelor's degree in Computer Engineering from Al-Mustansiriya University

Master's degree from Tambov State Technical University in Russia

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Content list

Introduction

Artificial intelligence of things (AIoT) is the combination of artificial intelligence (AI) technologies and the internet of things (IoT) infrastructure. AIoT's goal is to create more efficient IoT operations, improve human-machine interactions and enhance data management and analytics.

AI is the simulation of human intelligence processes by machines, especially computer systems, and is typically used in natural language processing, speech recognition and machine vision.

IoT is a system of connected devices, mechanical and digital machines, or objects with unique identifiers with the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. A *thing* in IoT can be a person's heart monitor implant, an automobile with built-in sensors to alert the driver when tire pressure is low or any other object that can be assigned an IP address and transfer data over a network.

In AIoT devices, AI is embedded into infrastructure components, such as programs and chipsets, which are all connected using IoT networks. Application programming interfaces (APIs) are then used to ensure all hardware, software and platform components can operate and communicate without effort from the end user.

When operational, IoT devices create and gather data, and then AI analyzes it to provide insights and improve efficiency and productivity. Insights are gained by

AI systems using processes such as data learning. Primarily, AIoT systems are set up either as cloud-based or edge-based.

Commonly referred to as IoT cloud, cloud-based IoT is the management and processing of data from IoT devices using cloud computing platforms. Connecting IoT devices to the cloud is essential since that's where data is stored, processed and accessed by various applications and services.

Cloud-based AIoT is composed of the following four layers:

1. **Device layer.** This includes several types of hardware, including tags, beacons, sensors, cars, production equipment, embedded devices, and health and fitness equipment.
2. **Connectivity layer.** This layer comprises fields and cloud gateways consisting of a hardware or software element that links cloud storage to controllers, sensors and other intelligent devices.
3. **Cloud layer.** This consists of data processing via an AI engine, data storage, data visualization, analytics and data access via an API.
4. **User communication layer.** This layer is made up of web portals and mobile applications.

AIoT data can also be processed at the edge, meaning the data from IoT devices is processed as close to these devices as possible to minimize the bandwidth needed to move data, while avoiding possible delays to data analysis.

Edge-based AIoT consists of the following three layers:

1. **Collection terminal layer.** This covers a range of hardware devices, such as embedded devices, cars, manufacturing equipment, tags, beacons, sensors,

mobility devices, and health and fitness equipment that are connected to the gateway over existing power lines.

2. **Connectivity layer.** This consists of the field gateways that the collection terminal layer is connected to over existing power lines.
3. **Edge layer.** This layer includes facilities for data storage, data processing and insight generation.

Applications and examples of AIoT

Although many AIoT applications focus on the implementation of cognitive computing in consumer appliances, the following are several examples of the wider use of AIoT:

- **Smart cities.** Smart technology, such as sensors, lights and meters, are used to collect data that's designed to help improve operational efficiency, drive economic growth and improve the quality of life for residents.
- **Smart retail.** Retailers use smart cameras to recognize shoppers' faces and detect if they've scanned their items at the self-checkout before leaving the store.
- **Smart homes.** Smart appliances learn through human interaction and response. AIoT appliances can also store and learn from user data to understand user habits to provide customized support.
- **Smart office buildings.** AI and IoT converge in smart buildings. Companies opt for a network of smart environmental sensors installed within their offices that detect the presence of people and automatically alter the lighting and temperature to maximize energy savings. In addition, facial recognition

technology enables smart buildings to control access by using linked cameras and AI to compare live photos with a database to determine who gets access.

- **Enterprise and industrial.** Manufacturers use smart chips to detect when equipment isn't functioning properly or a part needs to be replaced.
- **Social media and human resources (HR).** AIoT tools can be integrated with social media and HR-related platforms to create an AI decision-as-a-service function for HR professionals.
- **Autonomous vehicles.** These vehicles rely on multiple video cameras and sensor systems to gather data about nearby vehicles, monitor driving conditions and look for pedestrians.
- **Autonomous delivery robots.** Sensors gather data about the robot's environment -- for example, a warehouse -- and then use AI to make traversal-based decisions.
- **Healthcare.** Medical devices and wearables collect and monitor real-time health data, such as heart rate, and can detect irregular heartbeats.
- **Wearable devices.** Wearable technology can monitor and analyze personal health data to offer insights into a person's fitness, sleep and general well-being.
- **Collaborative robots (cobots).** Cobots are intended to assist people in the manufacturing and assembly of components. They aid humans in various tasks, such as production, assembly, packaging and quality control of products, by using data from IoT devices and AI tools, including computer vision.
- **City brains.** City brains are intended to promote urban development by combining machine intelligence and real-time municipal data. For example, intelligent AIoT systems can process massive logs, videos and data streams

from systems and sensors throughout an urban center to detect issues such as illegal parking, road accidents and changing traffic lights.

Benefits of AIoT include the following:

- **Increased operational efficiency.** AI-integrated IoT devices can analyze data to reveal patterns and insights and adjust system operations to become more efficient.
- **Ability to adjust on the fly.** Data can be generated and analyzed to identify points of failure, which enable the system to make adjustments as needed.
- **Data analytics.** Employees don't have to spend as much time monitoring IoT devices, thus saving money.
- **Scalability.** The number of devices connected to an IoT system can be increased to optimize existing processes or introduce new features.
- **Transformational technology.** AIoT is transformational and mutually beneficial for both types of technology, as AI adds value to IoT through machine learning capabilities and improved decision-making processes. IoT adds value to AI through connectivity, signaling and data exchange. AIoT can improve businesses and their services by creating more value from IoT-generated data.
- **Enhanced security.** IoT devices can be susceptible to security risks. However, AI can identify and avert these risks since AI algorithms can analyze data from sensors to discover anomalies and potential security breaches. For example, AI can analyze security camera footage to spot suspicious activity and notify security staff.
- **Reduced human error.** Businesses lose millions of dollars each year as a result of human error. By integrating machine learning with IoT technology,

organizations can effectively reduce errors. In normal workflows, data must pass through multiple phases or locations, creating more opportunities for human errors, such as data entry mistakes, to occur. AIoT mitigates these risks by analyzing information at its source. Minimizing data movement and reducing the number of intermediaries involved decrease the chances of errors significantly.

- **Personalization.** While IoT devices can gather information about user preferences and behavior, AI can use this information to further tailor user experiences. For example, a smart speaker can use AI to learn a user's musical preferences and generate customized playlists automatically.

Along with its benefits and use cases, there are also instances where AIoT could fail, causing a backup in production or other negative consequences. For example, autonomous delivery robots that fail might cause a delay in the delivery of a product; smart retail stores could fail to read a customer's face, leading to the customer accidently stealing a product; or an autonomous vehicle might fail to read its surroundings, such as an oncoming stop sign, and cause an accident.

The following are some additional challenges associated with AIoT:

- **Cybersecurity issues.** The growing number of devices connected through AIoT increases the risk of cyber attacks and security breaches.
- **Complexity.** IoT and AI technology integration can be challenging and demand particular knowledge and abilities.
- **Data management concerns.** Effective data management strategies are required for processing the data gathered from various sensors.
- **High cost.** Due to the need for specialized equipment, software and employees, executing AIoT technologies can be costly.

- **Privacy concerns.** There are concerns about how data acquired by AIoT devices is handled and stored, which could result in privacy issues and violations.

The future of AIoT

With the integration of AI, IoT creates a much smarter system. The goal is to have these systems make accurate judgments without the need for human intervention.

Digital transformation and the collaboration between AI and IoT have the potential to tap into unrealized customer value in several industry verticals, including edge analytics, autonomous vehicles, personalized fitness, remote healthcare, precision agriculture, smart retail, predictive maintenance and industrial automation.

Popular and emerging trends of AIoT include the following:

- **Edge computing.** This technology focuses on processing data in proximity to its source instead of relying on centralized cloud servers, offering benefits such as decreased latency, enhanced efficiency and reduced network congestion.
- **Swarm intelligence.** Swarm intelligence involves the coordinated behavior of decentralized and self-organized systems. Inspired by natural swarms, such as bees or ants, this technology can be applied to optimize the functioning of IoT devices.
- **5G technology.** One of the bigger possible innovations in AIoT is the inclusion of 5G. 5G is designed to enable faster transfer of large data files in IoT devices through its higher bandwidth and lower latency.

- **Operational efficiencies.** AIoT could help solve existing operational problems, such as the expense associated with effective human capital management or the complexity of supply chains and delivery models.
- **Computer vision.** The goal of computer vision is to make machines comprehend and interpret visual information gleaned from the real production environment. It can analyze video streams from cameras, recognize objects and spot anomalies in AIoT applications, enabling in-the-moment automation, monitoring and optimization. Computer vision is revolutionizing the industrial sector, especially in the context of Industry 4.0, by empowering companies to improve operational efficiency, place quality control procedures, enhance preventative maintenance practices and prioritize worker safety measures.

Artificial Intelligence in agriculture is a tool that looks like something out of science fiction, but in reality is being implemented for the benefit of worldwide producers, especially for those who work with precision farming.

In this type of agriculture, they use a set of technologies applied to the field, in order to gather the necessary information for decision-making that the farmer must anticipate. This is how they determine what to plant, where, when, and can even predict the volume of their crops.

Hence, it relies on artificial intelligence (AI), machines perform tasks that can be technical or the imitation of inductive and deductive processes of human thought. To achieve this, scientists rely on electronic circuits and sophisticated computer programs, which are fed with data to electronically copy the functioning of the brain.

This type of “learning” is a method of computing in which programmers do not place a specific function, but train the computer to recognize patterns. For example, they learn the behavior of healthy and diseased leaves to determine where to spray an herbicide and where not to. Thanks to these algorithms, machines can also determine when it is an outbreak, and when it is a weed.

AI only works if it is applied to specialized machines that fulfill specific functions and are programmed to fulfill a previously established objective. In agriculture, one of the scopes with the greatest potential is the analysis of information from abroad, that is, knowing how crops develop in their environment and, with this information, making predictions.

The data to apply AI in agriculture is usually taken by means of sensors, drones, or tractors, and then suggest to the farmers the actions they must carry out throughout their agricultural year.

An example of this is taking into account the way in which the rains have behaved in different periods and, based on that, choosing an irrigation method or even a change in crop type.

Crops require water retained in the soil to carry out physiological and biological processes. This is known as water requirements.

This demand for resources varies depending on the crop, environmental conditions, land management, and the growth phase in which it is found. To solve it, there are cultivation guides, but these guides only include general suggestions for the preparation of the land and do not analyze locally the needs of each producer, that is why the use of applications that work with the specific information of each one is so relevant.

These technologies could especially benefit regions where the problem is accentuated by the high variability of the rains and the dependence of farmers on storm practices, a type of agriculture that depends on the behavior of the rain during production cycles and the ability of the soil to capture and conserve moisture. The uncertainty caused by these practices are a burden for producers, who are affected by shortages of rain, delays, hail and even drought since the only source of water for their seasonal crops is precipitation.

In addition to this, FAO anticipates that climate change will affect agricultural practices, becoming a risk to food security and to the work of a large part of the population worldwide. Thus, promoting innovations of this type is an urgent activity to maintain and even increase agricultural productivity.

The world's population is assumed to be nearly 10 billion by 2050, boosting agricultural order -in a situation of humble financial development by somewhere in the range of 50% contrasted with 2013 (FAO, 2017).

At present, about 37.7% of total land surface is used for crop production (World Bank, 2015). From employment generation to contribution to National Income, agriculture is important. It is contributing a significant portion in the economic prosperity of the developed nations and is playing an active part in the economy of the developing countries as well.

The augmentation of agriculture has resulted in a significant increase in the per -capita income of the rural community. Thus, placing a greater emphasis on agricultural sector will be rational and apposite.

For countries, like India, the agricultural sector accounts for 18% of GDP and provides employment to 50% of the country's workforce. Development in the agricultural sector will boost the rural development, further leading towards rural transformation and eventually resulting in the structural transformation. With the advent of technology, there has been observed a dramatic transformation in many of the industries across the globe.

Surprisingly, agriculture, though being the least digitized, has seen momentum for the development and commercialization of agricultural technologies.

Artificial Intelligence (AI) has begun to play a major role in daily lives, extending our perceptions and ability to modify the environment around us (Kundaliya et al., 2020; Gandhi et al., 2020; Ahir et al., 2020).

Plesson (2019) gave a method for harvest planning based on the coupling of crop assignment with vehicle routing is presented. With this emerging technologies the workforce which were restricted to only a minimal industrial sectors are now contributing to numerous sectors. AI is based on the vast domains like Biology, Linguistics, Computer Science, Mathematics, Psychology and engineering.

Jha et al.(2019) a brief overview of the current implementation of agricultural automation. The paper also addres ses a proposed system for flower and leaf identification and watering using IOT to be implement ed in the botanical farm (Patel et al., 2020).

The basic concept of AI to develop a technology which functions like a human brain (Parekh et al., 2020; Jani et al., 2019) This technology is perpetrated by studying how human brain thinks, how humans learn, make decisions, and work while solving a problem, and on this ground intelligent software and systems are developed.

These software are fed with training data and further these intelligent devices provide us with desired output for every valid input, just like the human brain. Vast domains including Machine Learning and Deep learning are core part of AI (Patel et al., 2020; Pandya et al., 2020; Sukhadiya et al., 2020). While AI is the science of making intelligent machines and programs, ML is the ability to learn something without being explicitly programmed and DL is the learning of deep neural networks.

The main subjective of AI is to make problem solving facile which may include the use of ANN (Shah et al., 2020). ANN is a processing algorithm or a hardware whose functioning is inspired by the design and functioning of a human brain (Shah et al., 2020). Neural networks have a remarkable ability ofself-organization, and adaptive learning. It has replaced many traditional methods in numerous fields like Computer Science, Mathematics, Physics, Engineering image/ signal processing, Economic/ Finance, Philosophy, Linguistics, Neurology.

ANN undergoes the process of learning. Learning is the process of adapting the change in itself as and when there is a change in environment. There are two learning techniques, supervised learning and unsupervised learning.

The work of Jha et al., 2019, encloses the connected relations between the various embedded s ystems and the AI technology coherent with the agricultural field, it gave a brief about the various applications of neural networks, ML in this sector for precision farming.

AI is an emerging technology in the field of agriculture. AI -based equipment and machines, has taken today's agriculture system to a different level. This technology has enhanced crop production and improved real-time monitoring, harvesting, processing and marketing.

The latest technologies of automated systems using agricultural robots and drones has made a tremendous contribution in the agro-based sector. Various hi-tech computer based systems are designed to determine various important parameters like weed detection, yield detection and crop quality and many other techniques (Liakos et al., 2018).

The technologies used for the automated irrigation, weeding and spraying to enhance the productivity and reduce the work load on the farmers. Various automated soil sensing techniques are discussed. Hemalatha and Sujatha (2015) brought together temperature and moisture sensors to close the loop holes of the vehicle predictions. The robots used in sensing were localized by GPS modules and the location of these robots was tracked using the google maps.

The data from the robots was fetched through Zigbee wireless protocol. The readings were displayed on the 16X2 LCD displays which were integrated to the LPC2148 microcontroller. The latest automated weeding techniques are discussed and the implementation of drones for the purpose of spraying in the fields is discussed followed by the types of sprayers utilized on UAVs.

Further speaking about drones, yield mapping and monitoring is discussed beginning with the an outline of the yield mapping process followed by the programming of the software and briefing about the calculation as well as calibration process.

Farmers have always collected and evaluated a large amount of data each growing season. It started in ledger books. Then it was moved to spreadsheets, which were eventually saved on USB drives. Now, we have real-time reports enabled by field monitoring equipment, enriched by artificial intelligence (AI), and available to farmers on tablets and smartphones.

New digital tools offer farmers customized insights with a few taps on a screen. Today, this digital transformation is changing the way farmers can spend their days and make decisions on the farm. My experiences in agriculture have allowed me to see this transition firsthand.

Growing up in India, I used to visit my grandparents in Punjab and go to their cotton and wheat farms. My memories from those days include farmers riding bullock-driven carts, tilling the fields, applying fertilizer by hand, and harvesting crops using manual tools. That perception of the farm, although idyllic and simple, is actually outdated, old-fashioned, and inefficient.

Equipment, AI, and automation are helping farms of all sizes produce enough while using fewer natural resources. AI-based digital tools are enhancing decision-making in almost every field. Farmers can use a sophisticated mix of data, analytics, hardware and software, and unique algorithms to go beyond what the eye can see to make informed decisions about their operations.

AI can also help farmers select the best seeds, apply crop protection exactly where it is needed, or diagnose plant diseases threatening their crops in real-time.

Today at Bayer, we are applying AI to develop better products, make our supply chain more efficient, and improve customer experience for farmers.

We are combining AI with all of our R&D platforms — plant breeding, plant biotechnology, crop protection, ag biologicals, and digital advisors — and developing solutions by integrating all of these platforms. Much like the iconic launch of the iPhone as a device that integrated the phone, iPod, and internet into one device, we are aiming to deliver simplified and personalized integrated solutions to address the diverse needs of farmers. AI supports these efforts.

We've been on this journey for years now, and during that time we've identified five key elements for success in AI:

1. Asking the right questions to provide the most value
2. Availability of data along with the ability to cleanse, steward, and secure information
3. Diversified talent to bring the right domain, math, and engineering knowledge
4. Technology to process the data at scale
5. Partnerships to accelerate innovation

We've been making steady progress in each of these areas, which has led us to make advances and innovations that are delivering value to farmers. Time and again, we have seen that combining human ingenuity with artificial intelligence is more powerful than artificial intelligence on its own. Together we can change the way farmers grow.

The first AI program, The Logic Theorist, was designed by Newell and Simon in 1955. The term Artificial Intelligence was coined by John McCarthy who is regarded as the father of AI. During the early 1980s and 1990s, the rule based expert system was extremely used, but from 1990 onward, artificial neural network (ANN) model and fuzzy inference systems have taken the dominant role. There are three major AI techniques such as expert system, artificial neural network and fuzzy system.

In recent years an uprising use of hybrid system such as neuro-fuzzy or image processing coupled with artificial neural network are being used. AI is the simulation of human intelligence processes by machines and computer systems. Major sub-fields of AI include neural networks, machine learning, expert systems, speech processing, natural language processing, robotics and planning. There are several types of AI such as artificial general intelligence (AGI), artificial narrow intelligence (ANI), artificial superhuman intelligence (ASI). It moves toward more automated and more accurate systems that act on real-time.

AI technique is a manner to organize and use the knowledge efficiently in such a way that it could be perceivable by the people who provide it. It should be easily modifiable to correct errors and used in many situations. AI is becoming the important part of our daily life. Our life is changed by AI because this technology is used in a wide area of day to day services such as speech recognition, machine vision.

Internet of Things (IOT) includes tools such as robotics, drones, GPS & remote sensing technologies and computer imaging. Various low-cost sensors on field and in space helps in determining soil conditions, groundwater levels, Chlorophyll Index highlights crop stress in time, ensuring harvest productivity at each crop stages.

The adoption of IoT devices in agriculture is on the boom, which speaks a testimony in implementing technology-based data-driven agricultural practices.

Artificial Intelligence in agriculture is the creation and study of computers and software's capable of intelligent behavior which helps in creating 'Self Learning Algorithms & Capabilities', leading to automation on-ground agriculture practices. Farm activities such as field sowing, ploughing, fertilizer application, insecticide spray, and harvesting, weeding and post-harvest land-replenishing can be carried out by the applications and processes developed around AI. AI comes as a great boon to the agricultural sector which is slowly but surely making its presence in agricultural sector.


AI

AI Is Transforming Agriculture

Agriculture and farming is one of the oldest and most important professions in the world. Humanity has come a long way over the millennia in how we farm and grow crops with the introduction of various technologies. As the world population continues to grow and land becomes more scarce, people have needed to get creative and become more efficient about how we farm, using less land to produce more crops and increasing the productivity and yield of those farmed acres.

Worldwide, agriculture is a $5 trillion industry, and now the industry is turning to AI technologies to help yield healthier crops, control pests, monitor soil and growing conditions, organize data for farmers, help with workload, and improve a wide range of agriculture-related tasks in the entire food supply chain.

AI helping analyze farm data

Farms produce hundreds of thousands of data points on the ground daily. With the help of AI, farmers can now analyze a variety of things in real time such as weather conditions, temperature, water usage or soil conditions collected from their farm to better inform their decisions. For example, AI technologies help farmers optimize planning to generate more bountiful yields by determining crop choices, the best hybrid seed choices and resource utilization.

AI systems are also helping to improve harvest quality and accuracy -- what is known as precision agriculture. Precision agriculture uses AI technology to aid in detecting diseases in plants, pests, and poor plant nutrition on farms. AI sensors can detect and target weeds and then decide which herbicides to apply within the right buffer zone. This helps to prevent over application of herbicides and excessive toxins that find their way in our food.

Farmers are also using AI to create seasonal forecasting models to improve agricultural accuracy and increase productivity. These models are able to predict upcoming weather patterns months ahead to assist decisions of farmers. Seasonal forecasting is particularly valuable for small farms in developing countries as their data and knowledge can be limited. Keeping these small farms operational and growing bountiful yields is important as these small farms produce 70% of the world's crops.

In addition to ground data, farmers are also taking to the sky to monitor the farm. Computer vision and deep learning algorithms process data captured from drones flying over their fields. From drones, AI enabled cameras can capture images of the entire farm and analyze the images in near-real time to identify problem areas and potential improvements. Unmanned drones are able to cover far more land in much less time than humans on foot allowing for large farms to be monitored more frequently.

AI tackles the labor challenge

With less people entering the farming profession, most farms are facing the challenge of a workforce shortage. Traditionally farms have needed many workers, mostly seasonal, to harvest crops and keep farms productive.

However, as we have moved away from being an agrarian society with large quantities of people living on farms to now large quantities of people living in cities less people are able and willing to tend to the land. One solution to help with this shortage of workers is AI agriculture bots.

These bots augment the human labor workforce and are used in various forms. These bots can harvest crops at a higher volume and faster pace than human laborers, more accurately identify and eliminate weeds, and reduce costs for farms by having a round the clock labor force.

Additionally, farmers are beginning to turn to chatbots for assistance. Chatbots help answer a variety of questions and provide advice and recommendations on specific farm problems. Chatbots are already being used in numerous other industries with great success.

Through the use of AI and cognitive technologies farms across the world are able to run more efficiently, with less workers than before while still meeting the world's food needs. There is no more fundamental need than the need of food, and this will never go away. Fortunately, the use of AI will allow farms of all sizes to operate and function keeping our world fed. Through the use of agricultural AI and cognitive technologies, farms across the world are able to run more efficiently to produce the fundamental staples of our dietary lifestyles.

The Plantix app uses machine learning to detect crop pests and diseases and provides tips on how to treat them - helping ensure greater food security and secure the livelihoods of small farmers.

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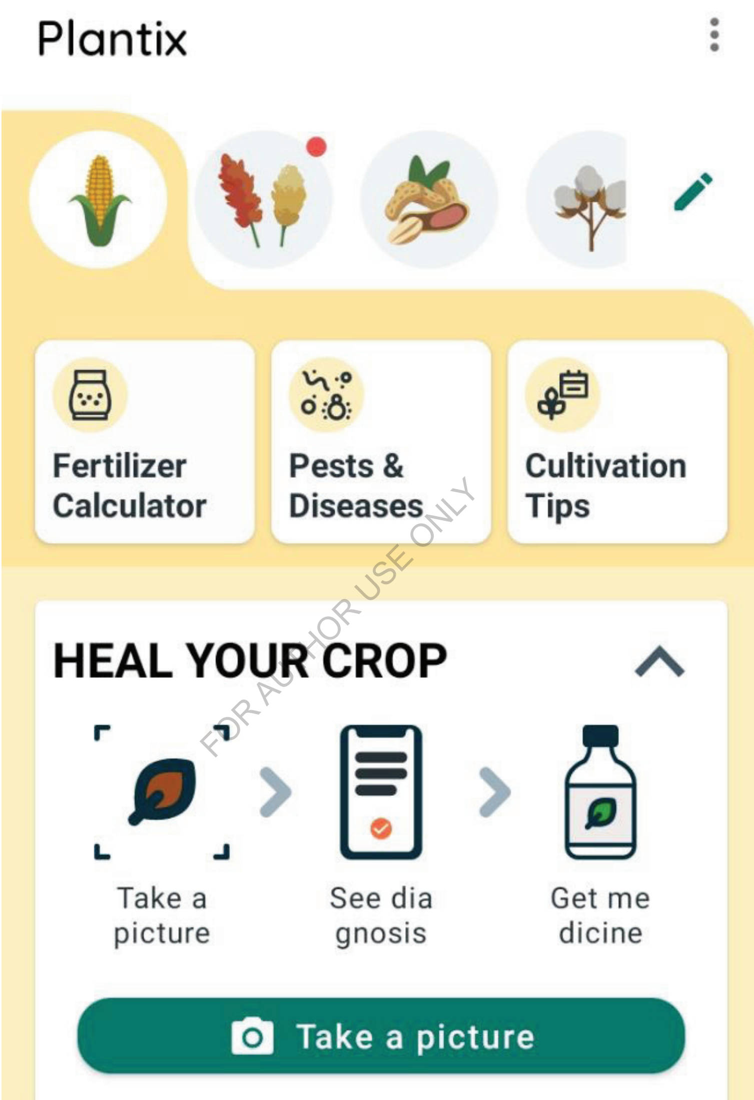
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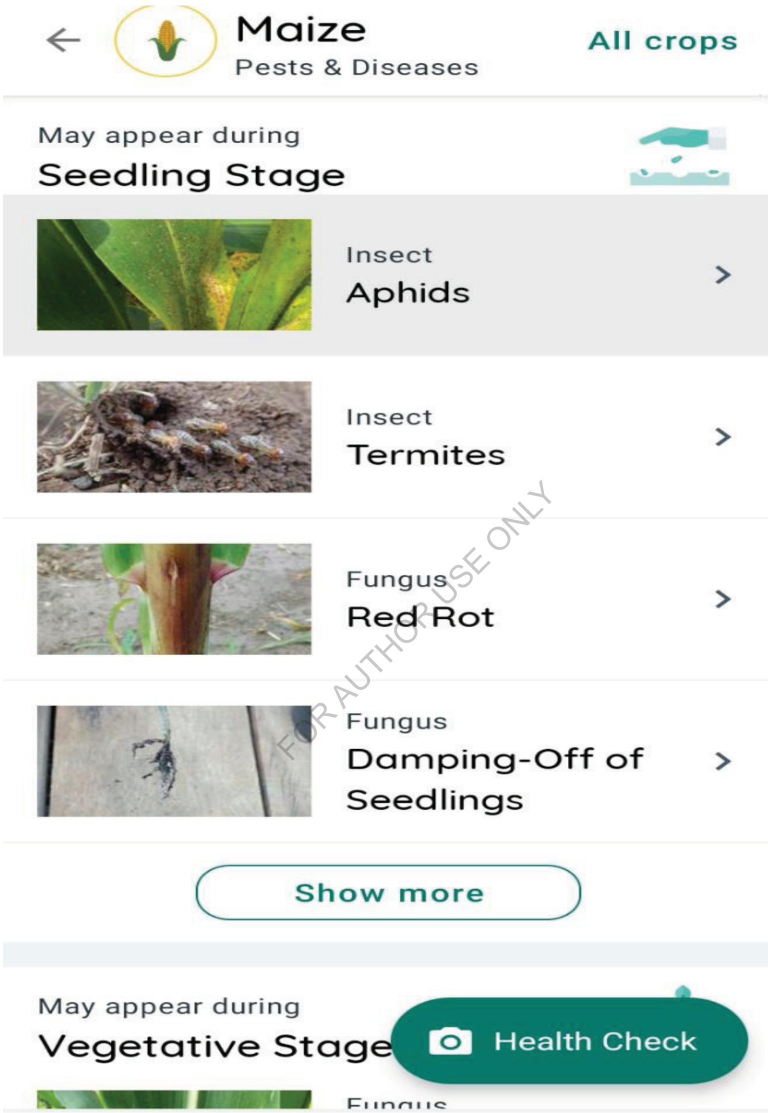
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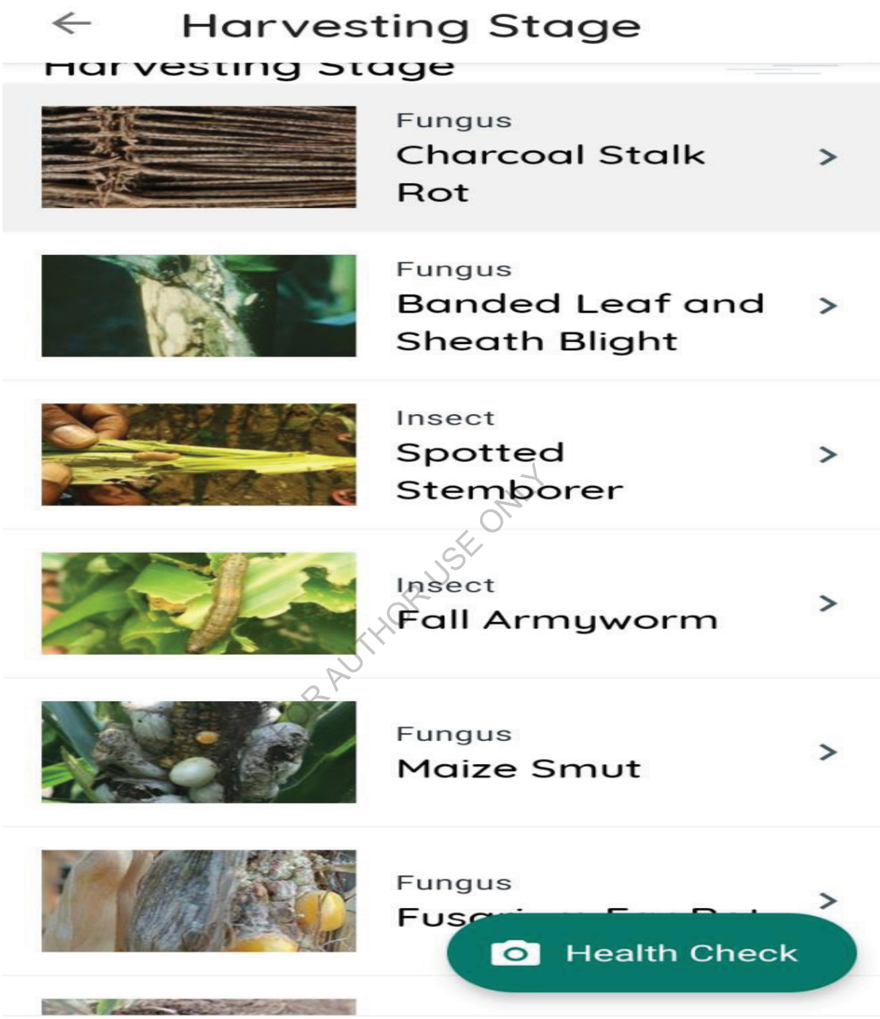
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Health Check

Until recently, artificial intelligence sounded like something from a far away future. But it's already popping up all over the place in our everyday lives: in speech and facial recognition on our smartphones, automatic translation tools and online customer service chatbots.

The range of possible applications of AI is huge, and constantly expanding. And its potential for use in agriculture is growing too.

Agriculture production is currently facing a huge variety of different challenges all over the world - due to the increasing demand for food from a steadily growing population, fierce competition for dwindling natural resources such as soil and water, the loss of biodiversity and the effects of climate change.

Last but not least, pests and plant diseases - which damage harvests, reduce the availability of food and increasing food costs - also pose a threat to global food security.

According to the FAO, plant pests and diseases are responsible for losses of 20-40% of global food production. This is a huge amount, especially when you consider that an estimated 820 million people around the world don't have enough to eat.

The **Berlin-based startup PEAT** is tackling this problem with **its Plantix app**. Take a photo of a plant infected by a disease or pest and the app will analyse the photo, compare it with existing information and provide information about the plant's health.

It will also provide options for treating it - not just chemical treatment methods, but also preventative measures.

For example, instead of using pesticides, they recommend tackling spider mite infestations with a combination of biological and preventative methods -

applying rapeseed, basil and neem oils, introducing spider mites' natural predators, as well as weeding and ensuring plants are well hydrated.

Plantix specialises primarily in agricultural crops that are important for the global food supply, such as bananas, wheat, rice, soybeans and corn.

Each photo sent in and analysed expands the database's knowledge pool and enables increasingly accurate diagnoses.

According to PEAT, the software can already detect plant diseases and pests with an accuracy of up to 95 percent, since each plant disease, pest or nutrient deficiency leaves a specific pattern.

When even AI doesn't have the answer...

If no suitable solution for the problem can be found via the AI, then users can turn to the community for help. Here, uses can post pictures and questions and have their queries answered by experts.

The service has the potential to be of enormous help for small farmers, especially in the Global South. People who only have a small area of land to grow crops to feed themselves and their families are dependent on good yields. A poor harvest can quickly endanger livelihoods and the expert knowledge supplied by agricultural organisations often doesn't reach the wider masses. With smartphones and the necessary network coverage becoming increasingly available in remote areas of the world, a solution like this could save harvests and livelihoods too.

Another possible application of Plantix's plant recognition software is to increase knowledge about the spread of diseases. "About 50,000 images are sent in daily via the app and analysed by the neural networks.

These images contain different information such as location and disease. Using this data, PEAT is able to follow the spread of diseases in real time and also model how diseases spread, and which factors encourage or hinder their spread," explained Korbinian Hartberger of PEAT to RESET.

The application was first trialled back in 2018, when the invasive butterfly species "fall armyworm" made its first appearance in Asia, becoming particularly prevalent in India.

The butterfly is originally native to the American continent, but has since been introduced to Africa and has now become a plague in Asia too. It causes significant yield losses in corn, rice, sorghum, millet and other plants. According to **FAO estimates for 2018**, up to 17.7 million tons of corn were lost to the pest in Africa alone.

This amount of corn could feed several million people and represents an economic loss of up to 4.6 billion USD.

PEAT has compiled the information collected on the status of the "fall armyworm" in **an interactive map** that shows how far the pest has spread, giving farmers time to at least take preventive countermeasures and partially protect their crops.

The Plantix app is available to download free for Android.

Crop Management in Agriculture

General crop management system provides an interface for overall management of crops covering each aspect of farming. Issues pertaining to soil and irrigation management are very vital in agriculture. Improper irrigation and soil management lead to crop loss and degradation quality. Application of herbicides has a direct implication on human health and environment as well.

Modern AI methods are being applied to minimize the herbicide application through proper and precise weed management. Insect pest infestation is one of the most alarming problems in agriculture that lead to heavy economic losses. Researchers have tried to mitigate this menace by development of computerized system that could identify the active pests and suggest control measures. Crop diseases are also a matter of grave concern to a farmer.

Significant expertise and experience is required so as to detect an ailing plant and to take necessary steps for recovery. Computer-aided systems are being used globally to diagnose the disease and to suggest control measures.

Agriculture is a dynamic domain where solutions cannot be generalized to suggest a common solution.

AI techniques have enabled us to capture the intricate details of each situation and provide a solution that is best fit for that particular problem. AI can be employed for agricultural product monitoring and storage control. Storage, drying and grading of the harvested crops are important aspects of agriculture. Hence, AI can be employed in addressing various food monitoring and quality control mechanisms. The crop yield prediction is very beneficial for marketing strategies and crop cost estimation.

Artificial Intelligence can alter the future of Indian agriculture which is primarily dependent on unpredictable climatic conditions. AI is being applied in every nook and corner of human endeavours but agriculture has fallen behind its adoption.

AI is basically the simulation of human intelligence by computer systems. AI has potential to think, learn and act in response to its immediate environment according to its programmed objectives.

AI-driven technologies can take over planting, irrigation, maintaining, harvesting crops and detect certain disease in plants, leading to save money, energy, labour and resources. Technologies such as satellite image analysis, machine learning and cloud computing are revolutionizing agriculture. These technologies are helping farmers through the timely delivery of weather information, prices and automated calls to protect their crops from pests and weeds. These predictions are primarily based on weather conditions and other factors. Statistically predictions and Machine Learning (ML) play important roles in these processes.

A central task force on Artificial Intelligence has suggested creating a National Artificial Intelligence Mission (N-AIM) that will serve as a nodal agency for coordinating AI related activities in the country. Professor V Kamakoti, a Professor of IIT, Madras is the chairman of the task force and members include those from government, academia and the private sector. According to the report of the task force, set up by the Union Commerce Ministry, AI is the science and engineering of making intelligent machines, especially intelligent computer programmes and it should be seen as a scalable problem solver in India rather than only as a booster of economic growth. The task force has identified ten domains in India including Agriculture and Food Processing for implementation.

Application of AI in agriculture broadly comprises soil and crop monitoring which involve in use of IoT and sensors technologies to monitor soil and crop health, predictive farming analytics which involve in using machine learning to help farmers plan for sowing and reaping calendar, and supply chain efficiencies which involves in using analytics to optimize the supply chain.

Internet of Things (IOT) includes tools such as robotics, drones, GPS & remote sensing technologies and computer imaging. Various low-cost sensors on field and in space helps in determining soil conditions, groundwater levels, chlorophyll index highlights crop stress in time, ensuring harvest predictivity at each crop stages. The adoption of IoT devices in agriculture is on the boom, which speaks a testimony in implementing technology-based data-driven agricultural practices. AI-based technologies applications in agriculture of these categories are used by various companies.

Companies/Startups using AI-based Technologies in Agriculture

Microsoft has begun empowering small-holder farmers in India to increase their income through greater price and higher crop yield. Microsoft is working with 175 farmers in Andhra Pradesh, India to provide advisory services for sowing, land preparation, fertilizer applications.

International Crops Institute for the Semi-Arid Tropics (ICRISAT) working with Microsoft launched an AI-based Sowing App which sends advice to the farmers about the date to sow and other advice. Moisture Adequacy Index (MAI) is used to calculate the crop-sowing period.

MAI is the standardized measure used for assessing the degree of adequacy of rainfall and soil moisture to meet the potential water requirement of crops. The App sends sowing advisories to participating farmers on the optimal date to sow crop. There is no need for farmers to install any sensor or device in their fields but only need a phone receiving a text message. This initiative has already resulted in 30% higher yield per hectare on an average compared to last year. Microsoft has also collaborated with United Phosphorous (UPL), India's largest producer of agrochemicals, to create the Pest Risk Prediction App based on AI and ML to forecast in advance the risk of pest attach.

Farmers across the Indian states of Karnataka, Andhra Pradesh, Maharashtra and Madhya Pradesh receive automated text message before sowing the seeds and voice calls for the alert of pest attack.

CropIn is a Bengaluru-based start-up company using AI to maximize per-acre value and claims to be an intelligent and self-evolving system delivering future-ready farming solutions to the agricultural sector. Basically, the CropIn uses proprietary machine learning algorithm built on satellite and weather data to give insight at plot and region level.

The company used to record arm data manually from 2500 plus potato plots spread across an area of 5200 plus acres. All plots were geo-tagged to find the actual plot area and the ‘smartfarm’ solution helped in remote sensing and weather advisory, scheduling and monitoring farm activities for complete traceability, educating farmers on adoption of right package of practices and inputs, monitoring heath and harvest estimation and alerts on pest and diseases.

The CropIn uses AI-driven technologies to help clients analyse and interpret data to derive real-time actionable insights on standing crop and its agri-business intelligence solution known as SmartRisk “leverages agri-alternate data and provides risk mitigation and forecasting for effective credit risk assessment and loan recovery assistance.

Intello Lab is a Bengaluru-based startup by IIT-Bombay alumnus Milan Sharma in May 2016. The company uses deep learning algorithms for image analysis and claims to provide image recognition technology which can recognize objects, faces, flora, fauna and tag them in any image. This new generation of intelligent image based applications provides insights on the crops’ health during the growing season and its final harvested quality by click of photograph.

Farmers can click on image of their crop and use their solution to understand the diseases, pests and weeds growing in their farms. The solution uses DL and image processing models to identify any crop diseases or pest infestation in the crops and also provides recommendations on how that disease can be cured and prevented from increasing further.

Gobasco is a company co-founded by Vedant Katyar, an engineering graduate from premier Indian technology institute BITS Pilani and Abhishek Sharma, CTO, is a doctorate in AI from the University of Maryland, USA. This company based in Uttar Pradesh,India uses AI and related technologies in the various stages of the agri-supply chain.

Real-time data analysis on multiple data-streams along with crowd-sourced from producer/buyer marketplaces and transporters feeds their automatic transaction discovery algorithms to obtain high-margin transactions. Crowd-sourced data, algorithms and analytics overcome the credit default problem, the most challenging problem of current supply-chain, to ensure a very low risk operation. Agri-Mapping involving a real-time agri map of commodities is obtained by deep-learning based satellite image analysis and crowd-sourced information fusion.

For creating an international agri-commodity standard, computer vision and AI-based automatic grading and sorting of vegetables and fruits is done for quality maintenance and reliable trading across country boundaries.

Gramophone is a based in the Madhya Pradesh, India and Tauseef Khan is the co-founder of the company. This company uses AI and ML for image recognition technology in tandem with proprietary database. Temperature and humidity data is used to guide and help farmers with timely information and right kind of inputs to achieve better yields. Pathology/entomology data is used to predict pest and disease risks. Gramphone is also used to forecast commodity prices for better price realization.

Jivabhumi co-founded by TS Srivatsa, is based on AI engine which leverage the comprehensive aggregation of data at various points in supply chain. The platform captures comprehensive information about the commodities regarding growing information, pre- and post-harvest, transportation, warehousing to generate a digital identity for a physical commodity and build traceability to prove provenance and movement of commodities from farm to table. This ‘Footprint’ is a produce aggregation and food traceability solution which provides e-marketplaces services and implements traceability.

Aibono is a Bengaluru-based company started and founded by Vivek Rajkumar, a graduate from IIT-Madras in 2014. Aibono, Ai standing for Artificial Intelligence and bono meaning for the public good, provide real-time precision agriculture services to farmers. In India, a majority of the farmers have small holding of 1.5-2 acres, are not in position to use technology or bring in experts to help them.

Aibono uses technology based on internet, broadband connectivity and smart phones and uses sensors on the field to collect soil data, leaf coloration or other images and upload it on the platform. The data is analyzed to recommend to the farmer what need to be done on the day-to-day basis. The company set up a model farm in Nilgiris, Tamil Nadu providing precision agriculture services to fruits and vegetables farmers. It tracks a large number of farm variables, uses data sciences to analyze that information and provides inputs to farmers. The farmers operating on Aibono's platform have seen their yields go up 1.8-2 times.

The Berlin-based agricultural tech startup 'PEAT' has developed the Plantix app that identifies potential defects and nutrient deficiencies in the soil. This application uses images to detect plant disease; a smart phone collects image which is match with server image and then a diagnosis of the plant health is generated. Thus AI and ML are used to solve threatening plant disease.

Blue River Technology, a US-based company, has developed a robot known as "*See and Spray*" which leverages computer vision to monitor and precisely spray weeds on cotton plants. Precision spraying can help to prevent herbicide resistance. The ability to control weeds is a top priority for farmers and an ongoing challenge because of herbicide resistance problem. About 250 species of weeds have become resistance to herbicides.

Harvest CROO Robotics, a US-based company has developed a robot to help strawberry farmers pick and pack their crops and claims that its robot can harvest eight acres in a single day and replace thirty human laborers. Lack of laborers has reportedly led to millions of dollars of revenue losses in key farming regions such as California and Arizona.

Automation is also emerging in an effort to help address challenges in the labor force. The industry is projected to experience a six percent decline in agricultural workers from 2014 to 2024.

SkySquirrel Technologies is one of the companies bring drone technology to vineyards. The company uses algorithms to integrate and analyze and the captured images and data to provide a detailed report on the health of the vineyard. The company aims to help farmers to improve their crops yield and to reduce costs. Users pre-programm the drone's route and once deployed the device will leverage computer vision to record images which will used for analysis and claims that its technology can scan a 50 acres in 24 minutes and provides data analysis with 95 per cent accuracy.

A Colorado-based company, 'aWhere', uses machine learning algorithms in connection with satellites to predict weather, analyze crop sustainability and evaluate farms for the presence of pest and diseases. The company claims to specialize in providing a high quality of data that is continuously updated at a rapid rate. Data sources include temperature, precipitation, wind speed, and solar radiation. It also provide its users (farmers, farm consultants, researchers) with access to cover a billion points of agronomic data on a daily basis.

FarmShots, a company based in Raleigh, North Carolina US, is a startup focused on analyzing agricultural data derived from images captured by satellites and drone to detect pest and disease infestations and nutrition status on farms. The company claims that its software can inform users exactly where fertilizer is needed and can reduce the amount of fertilizer used by nearly 40 per cent.

California-based 'Trace Genomics' provides soil analysis services to farmers. After submitting a sample of their soil to the company, users reported receive an in-depth summary of their soils contents. Services are provided in packages which include a pathogen screening focused on fungi and bacteria. The users can get information about a comprehensive microbial evaluation. The emphasis is on preventing defective crops and optimizing the potential for healthy crop production.

SatSure, a London-based startup, uses satellite data and ML techniques to assess imageries of farms and predict monetary prospect of their future yield. The company helps insurers and financers in deciding the value of agricultural land. 'Earth Food' and 'V Drone Agro' are other similar companies which use AI to assess soil conations over the cloud and provide services to help farmers so that they can get maximum yield returns.

Gamaya is Switzerland-based company which offer a drone-mounted hyperspectral imaging camera and claims combines remote sensing, machine leaning and crop science technologies. The camera measure the light reflected by plants within visible and infrared light spectrum. The plants with different physiologies and characteristics reflect light differently. This pattern changes as the plant grow and is affected by stressors.

Gamaya's technology is capable of mapping and distinguishing the weeds from plants. It is able to identify other plant stresses such as disease, malnutrition, and other chemical inputs in the soil.

Neurala has developed the Neurala Brain, a deep learning application which the company requires less training, less data storage and less computing resources. This application may be implemented in drones, camera, smartphone. Training the algorithms uses the company's Brain Builder data processing tool which enables users to upload and label their own sets.

To start the training process, the user much upload to the device about eight images per subject. Neural's algorithms will learn in 25 seconds. This is much faster than traditional deep neural networks which take more than 15 hours to be trained on a server and require 36 images per object.

Iris Automation developed the Iris Collision Avoiding Technology for Commercial drone, an application that allows drones to observe and interpret its surrounding and moving aircraft to avoid collision. This application is also suitable for use in agriculture where the drone application is capable of assisting farmers in surveying crops, controlling pests, planting seeds while interacting with other drones safely.

The system's computer vision gives it the ability to see obstacles, aircraft, and other potential dangers for a safe and reliable flight as it captures images of its surroundings during flight. Once the images are captured, the camera's deep learning algorithms process he data by finding similar images in its database to recognize the object. Recognizing the objects allows the drone to then know where to fly.

SenseFly offers the 'Ag360' computer vision drone which capture infrared images of fields to help farm owners monitor crops at different stages of growth and assess the condition of the soil. This could enable farmers to keep track of plant health and determine the amount of fertilizer needed to be applied to avoid wastage. During the flight, the drone captures the imaging data of the field while 'eMoton' then directly uploads these images to cloud services.

The 'Pix4Dfield' image processing application generates aerial maps of fields for crop analysis. Its algorithms translate the image data to create maps of the field by finding matching images within its database to recognize the condition of the plants and soil. Farmers, agronomists, soil scientists and breeders provide the inputs to train this application. The maps enable farmers to determine soil characteristics such as moisture and temperature, and provide guidance to improve crop growth and production.

Challenges and Future Prospects

Although the use of AI is promising but there are challenges when it comes to agriculture. The development of AI algorithms in agriculture is one of the most challenging jobs because of large amount of data requirement to train the algorithms.

Other challenges include non-availability of data from remote areas and availability of limited data once per year during the growing season only. Prediction in agriculture is still complex and elusive. Marketing is the critical factor in driving framers from poverty to prosperity.

NITI Aayog is working in this direction to solve these challenges by digitalization of agriculture. Digital India is reaching in villages of India for leveraging AI techniques in agriculture. NITI Aayog's Statement of Intent (SoI) to develop and deploy AI to provide real-time advisory to farmers should be extended all over the country. Even though in a nascent stage, AI is slowly but surely making its presence felt in the agricultural sector. Global use of AI for agriculture is quite impressive.

Agricultural robotics, soil and crop monitoring and predictive analytics are the major categories where AI based technology are used. Agriculture is slowly becoming digital with AI and using sensors, drones, robotics, satellite images, weather information, soil testing data, soil moisture and so on.

Drones in agriculture are used for soil and field analysis, planting, crop spraying, crop monitoring, irrigation, and health assessment. AI-driven drones can be used for more advanced data-gathering tools. Technologies such as Artificial Intelligence, cloud machine learning, satellite imagery and advanced analytics will empower the small-holder farmers to increase their income through higher crop yield and greater price control.

Artificial intelligence-powered tools are rapidly becoming more accessible, including for people in the more remote corners of the globe. This is good news for smallholder farmers, who can use handheld technologies to run their farms more efficiently, linking them to markets, extension workers, satellite images, and climate information.

The technology is also becoming a first line of defense against crop diseases and pests that can potentially destroy their harvests.

A new smartphone tool developed for banana farmers scans plants for signs of five major diseases and one common pest. In testing in Colombia, the Democratic Republic of the Congo, India, Benin, China, and Uganda, the tool provided a 90 percent successful detection rate.

This work is a step towards creating a satellite-powered, globally connected network to control disease and pest outbreaks, say the researchers who developed the technology.

"Farmers around the world struggle to defend their crops from pests and diseases," said Michael Selvaraj, the lead author, who developed the tool with colleagues from Bioversity International in Africa. "There is very little data on banana pests and diseases for low-income countries, but an AI tool such as this one offers an opportunity to improve crop surveillance, fast-track control and mitigation efforts, and help farmers to prevent production losses."

Co-authors included researchers from India's Imayam Institute of Agriculture and Technology (IIAT), and Texas A&M University.

Bananas are the world's most popular fruit and with the global population set to reach 10 billion in 2050, pressure is mounting to produce sufficient food. Many countries will continue depending on international trade to ensure their food security. It is estimated that by 2050 developing countries' net imports of cereals will more than double from 135 million metric tonnes in 2008/09 to 300 million in 2050.

An essential staple food for many families, bananas are a crucial source of nutrition and income. However, pests and diseases -- Xanthomanas wilt of banana, Fusarium wilt, black leaf streak (or Black sigatoka), to name a few -- threaten to damage the fruit. And when a disease outbreak hits, the effects to smallholder livelihoods can be detrimental.

In the few instances in which losses to the Fusarium Tropical race 4 fungus have been estimated, they amounted to US$121 million in Indonesia, US$253.3 million in Taiwan, and US$14.1 million in Malaysia (Aquino, Bandoles and Lim, 2013).

In Africa, where the fungus was first reported in 2013 in a plantation in northern Mozambique, the number of symptomatic plants rose to more than 570,000 in September 2015.

The tool is built into an app called Tumaini -- which means "hope" in Swahili -- and is designed to help smallholder banana growers quickly detect a disease or pest and prevent a wide outbreak from happening. The app aims to link them to extension workers to quickly stem the outbreak. It can also upload data to a global system for large-scale monitoring and control. The app's goal is to facilitate a robust and easily deployable response to support banana farmers in need of crop disease control.

"The overall high accuracy rates obtained while testing the beta version of the app show that Tumaini has what it takes to become a very useful early disease and pest detection tool," said Guy Blomme, from Bioversity International. "It has great potential for eventual integration into a fully automated mobile app that integrates drone and satellite imagery to help millions of banana farmers in low-income countries have just-in-time access to information on crop diseases."

Deep learning

Rapid improvements in image-recognition technology made the Tumaini app possible. To build it, researchers uploaded 20,000 images that depicted various visible banana disease and pest symptoms. With this information, the app scans photos of parts of the fruit, bunch, or plant to determine the nature of the disease or pest. It then provides the steps necessary to address the specific disease. In addition, the app also records the data, including geographic location, and feeds it into a larger database.

Existing crop disease detection models focus primarily on leaf symptoms and can only accurately function when pictures contain detached leaves on a plain background. The novelty in this app is that it can detect symptoms on any part of the crop, and is trained to be capable of reading images of lower quality, inclusive of background noise, like other plants or leaves, to maximize accuracy.

"This is not just an app," said Selvaraj. "But a tool that contributes to an early warning system that supports farmers directly, enabling better crop protection and development and decision making to address food security."

The potential of cutting-edge technologies such as AI, IoT (Internet of Things), robotics, satellites, cloud computing, and machine learning for the transformation of agriculture and for helping farmers.

An Artificial Intelligence and Cloud Based Collaborative Platform for Plant Disease Identification, Tracking and Forecasting for Farmers

Plant diseases are a major threat to farmers, consumers, environment and the global economy. In India alone, 35% of field crops are lost to pathogens and pests causing losses to farmers. Indiscriminate use of pesticides is also a serious health concern as many are toxic and biomagnified.

These adverse effects can be avoided by early disease detection, crop surveillance and targeted treatments. Most diseases are diagnosed by agricultural experts by examining external symptoms. However, farmers have limited access to experts. Our project is the first integrated and collaborative platform for automated disease diagnosis, tracking and forecasting.

Farmers can instantly and accurately identify diseases and get solutions with a mobile app by photographing affected plant parts. Real-time diagnosis is enabled using the latest Artificial Intelligence (AI) algorithms for Cloud-based image processing.

The AI model continuously learns from user uploaded images and expert suggestions to enhance its accuracy. Farmers can also interact with local experts through the platform. For preventive measures, disease density maps with spread forecasting are rendered from a Cloud based repository of geo-tagged images and micro-climactic factors. A web interface allows experts to perform disease analytics with geographical visualizations.

In our experiments, the AI model (CNN) was trained with large disease datasets, created with plant images self-collected from many farms over 7 months. Test images were diagnosed using the automated CNN model and the results were validated by plant pathologists. Over 95% disease identification accuracy was achieved. Our solution is a novel, scalable and accessible tool for disease management of diverse agricultural crop plants and can be deployed as a Cloud based service for farmers and experts for ecologically sustainable crop production.

Implementation of artificial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides

Impact of AI on agriculture

The technologies which are AI -based help to improve efficiency in all the fields and also manage the challenges faced by various industries including the various fields in the agricultural sector like the crop yield, irrigation , soil content sensing, crop - monitoring, weeding, crop establishment.

Agricultural robots are built in order to deliver high valued application of AI in the mentioned sector. With the global population soaring, the agricultural sector is facing a crisis, but AI has the potential to deliver much -needed solution.

AI - based technological solutions has enabled the farmers to produce more output with less input and even improved the quality of output , also ensuring faster go -to - market for the yielded crops.

By 2020, farmers will be using 75 million connected devices. By 2050, the average farm is expected to generate an average of 4.1 million data points every day. The various ways in which AI has contributed in the agricultural sector are as follows:

Image recognition and perception:

Jangwon Lee et al., 2016 said that in recent years, an increasing interest has been seen in autonomous UAVs and their applications including recognition and surveillance, human body detection and geolocalization, search and rescue, forest fire detection.[M. Bhaskaranand, and J. D. Gibson.,2011 , P. Doherty and P. Rudol , 2007, T.Tomic et al. , 2012, L. Merino et al , 2006].

Because of their versatility as well as amazing imaging technology which covers from delivery to photography, the ability to be piloted with a remote controller and the devices being dexterous in air which enables us to do a lot with these devices, drones or UAVs are becoming increasingly popular to reach great heights and distances and carrying out several applications.

Skills and workforce:

Deepak Panpatte , 2008 said that artificial intelligence makes it possible for farmers to assemble large amount of data from government as well as public websites, analyze all of it and provide farmers with solutions to many ambiguous issues as well as it povides us with a smarter way of irrigation which results in higher yield to the farmers.

Due to artificial intelligence, farming will be found to be a mix of technological as well as biological skills in the near future which will not only serve as a better outcome in the matter of quality for all the farmers but also minimize their losses and workloads.

UN states that, by 2050, 2/3rd of world's population will be living in urban areas which arises a need to lessen the burden on the farmers. AI in agriculture can be applied which would automate several processes, reduce risks and provide farmers with a comparatively easy and efficient farming.

Maximize the output:

Ferguson et al., 1991 said in his wok thatVariety selection and seed quality set the maximum performance level for all plants. The emerging technologies has helped the best selection of the crops and even has improved the selection of hybrid seed choices which are best suited for farmer's needs. It has implemented by understanding how the seeds react to various weather conditions, different soil types. By collecting this information, the chances of plant diseases are reduced. Now we are able to meet the market trends, yearly outcomes, consumer needs, thus farmers are efficiently able to maximize the return on crops.

Chatbots for farmers:

Chatbots are nothing but the conversational virtual assistants who automate interactions with end users. Artificial intelligence powered chatbots, along with machine learning techniques has enabled us to understand natural language and interact with users in away more personalized way. They are mainly equipped for retail, travel, media, and agriculture has used this facility by assisting the farmers to receive answers to their unanswered questions, for giving advice to them and providing various recommendations also.

Robots in agriculture

Robotics and Autonomous Systems (RAS) are introduced in large sectors of the economy with relatively low productivity such as Agri -Food .According to UK -RAS White papers (2018) the UK Agri -Food chain, from primar y farming through to retail, generates over £108bn p.a., and with 3.7m employees in a truly international industry yielding £20bn of exports in 2016.Robotics has played a substantial role in the agricultural production and management.

The researchers have now started emphasizing on technologies to design autonomous agricultural tools as the conventional farming machineries lacked in efficiency. The main purpose of coming up with this technology is to replace human labor and produce effective benefits on small as well as large scale productions. In this sector, the room for robotic technologies has amplified productivity immensely.

The robots are performing various agricultural operations autonomously such as weeding, irrigation, guarding the farms for delivering effective reports, ensuring that the adverse environmental conditions do not affect the production, increase precision, and manage individual plants in various unfamiliar ways.

The idea of coming up with such a technology came with the introduction of a machine called Eli Whitney's cotton gin. It was invented in 1794 by U.S . - born inventor Eli Whitney (1765 -1825), a device which revolutionized cotton production by significantly accelerating the process of extracting seed from cotton fiber. It created 50 pounds of cotton in one day .Thus this gave birth to the autonomous agricultural robots.

A basic automated model was introduced to determine the actual position of seeds (Griepentrog et al., 2005). Ultra high precision placement of seed was also established .Mechanisms that ensure that the seeds planted has zero ground velocity (Griepentrog et al., 2005). This is important as it ensures that the seed does not bounce from its actual position after the soil impact. The status or the development of plant was recorded by automated machines. Various biosensors were established to monitor the plant growth and also to detect plant diseases (Tothill , 2001).

The process of manual weeding was replaced by the laser weeding technology, where a mobile focused infra -red light disrupts the cells of the weeds, this beam was controlled by computers (Griepentrog et al., 2006). For the effective use of water, automated irrigation systems were also established.

Irrigation:

The agriculture sector consumes 85% of the available freshwater resources across the world. And this percentage is increasing rapidly with the population growth and with the increase in food demand. This leaves us with the need to come up with more efficient technologies in order to ensure proper use of water resources in irrigation.

The manual irrigation which was based on soil water measurement was replaced by automatic irrigation scheduling techniques. The plant evapo transpiration which was dependent on various atmospheric parameters such as humidity, the wind speed, solar radiations and even the crop factors such as the stage of growth, plant density, the soil properties, and pest was taken into consideration while implementing autonomous irrigation machines.

Kumar (2014) discusses about the different irrigation methods with the primary motive of developing a system with reduced resource usage and increased efficiency. Devices like fertility meter and PH meter are set up on the field to determine the fertility of the soil by detecting the percentage of the primary ingredients of the soil like potassium, phosphorous, nitrogen.

Automatic plant irrigators are planted on the field through wireless technology for drip irrigation. This method ensures the fertility of the soil and ensures the effective use of water resource. The technology of smart irrigation is developed to increase the production without the involvement of large number of man power by detecting the level of water, temperature of the soil, nutrient content and weather forecasting (Gupta et al., 2016). The actuation is performed according to the microcontroller by turning ON/OF the irrigator pump. The M2M that is, Machine to Machine technology is been developed to ease the communication and data sharing amongst each other and to the server or the cloud through the main network between all the nodes of the agricultural field (Shekhar et al. 2017).

They (2017) developed an automated robotic model for the detection of the moisture content and temperature of the Arduino and Raspberry pi3. The data is sensed at regular intervals and is sent to the microcontroller of Arduino (which has an edge level hardware connected to it), it further converts the input analog to digital. The signal is sent to the Raspberry pi3 (embedded with KNN algorithm) and it sends the signal to Arduino to start the water source for irrigation.

The water will be supplied by the resource according to the requirement and it will also update and store the sensor values. Jha et al., (2019) also developed an automated irrigation system with the technology of Arduino for reducing the man power and time consumption in the process of irrigation.

Savitha and UmaMaheswari (2018) also developed the idea of efficient and automated irrigation system by developing remote sensors using the technology of Arduino which can increase the production up to 40%. Another system for automated irrigation was given by Kandasamy and R (2018).

In this approach different sensors were built for different purposes like the soil moisture sensor to detect the moisture content in the soil, the temperature sensor to detect the temperature, the pressure regulator sensor to maintain pressure and the molecular sensor for better crop growth.

The installation of digital cameras

The output of all these devices is converted to digital signal and it is sent to the multiplexer through wireless network such as Zigbee and hotspot. The first technique was the subsurface drip irrigation process, which minimized the amount of water loss due to evaporation and runoff as it is directly buried beneath the crop. Later researchers came with different sensors which were used to detect the need of water supply to the fields as soil moisture sensor and rain drop sensor, which were instructed through wireless broadband network an d powered by solar panels.

The rain drop sensor and soil moisture sensor informs the farmer about the moisture content in the soil through SMS in their cell phone using GSM module. Accordingly the farmer can give commands using SMS to ON and OFF the water supply.

Thus we can consider that this system will detect part or area in the fields which required more water and could hold off the farmer from watering when it' s raining Soil moisture sensors uses one of the several technologies used to measure the soil moisture content. It is buried near the root zones of the crops (Dukes et. al, 2015).

The sensors help in accurately determining the moisture level and transmits this reading to the controller for irrigation. Soil moisture sensors also help in significantly conserving water (Qualls et al, 2007).

One technique of moisture sensors is the water on demand irrigation in which we set the threshold according to the soil's field capacity and these sensors permits your controller to water only when required. When the scheduled time arrives, the sensor reads the moisture content or level for that particular zone, and watering will be allowed in that zone only if the moisture content is below the threshold. The other was the suspended cycle irrigation which requires irrigation duration unlike the water on demand irrigation. It requires the start time and the duration for each zone.

Dielectric method:

The moisture in the soil is calculated by the sensors which basically evaluate the moisture content in the soil based on the dielectric constant (soil mass permittivity) of the soil. The amount of irrigation needed can also be determined on the basis of the dielectric constant (Gebregiorgis and Savage, 2006). (Kuyper andBalendonck, 2001) proposes an automated system that uses dielectric soil moisture sensors for real time irrigation control. The measurement method based on the dielectric properties is considered to be the most potential one (Zhen et. al, 2010).

Hanson et al.(2000) gave the information regarding how soil types affect the accuracy to dielectric moisture sensors. The dielectric steady is only the capacity of soil to transfer power or electricity. The soil is comprised of various parts like minerals, air and water, subsequently the estimation of its dielectric consistent is determined by the general commitment of every one of these segments. Since the estimation of the dielectric value of water (Kaw = 81) is a lot bigger than the estimation of this consistent for the other soil parts, the estimated value of permittivity is primarily represented by the nearness of moisture in the soil. One method to calculate the relationship between the dielectric constant (Kab) and volumetric soil moisture (VWC) is the equation of Topp et al.,:

$VWC = -5.3 \times 10 - 2 + 2.29 \times 10 - 2\ K\ a\ b - 5.5 \times 10 - 4\ K\ a\ b\ 2 + 4.3 \times 10 - 6\ K\ a\ b\ 3$ (1)

The other method used for determining the dielectric constant is the by the Time Domain Reflectometry (TDR). It is determined on the basis of the time taken by an electromagnetic wave to propagate along a transmission line that is surrounded by the soil. As we probably are aware, the propagation velocity (V) is an element of the dielectric constant (Kab), therefore it is legitimately corresponding to the square of the transmission time (t in a flash) down and back along the transmission line: $Kab = (c/v)\ 2 = (\ (ct\ ) / (\ 2\ L\ )\ )\ 2$ (2) Where c is the speed of electromagnetic waves in a vacuum (3•108 m/s or 186,282 mile/s) and L is the length of the TL in the soil (in m or ft)

Neutron Moderation:

This is another technique for deciding the moisture content in the soil. In this strategy fast neutrons are launched out from a decomposing radio dynamic source like 241Am/9Be (Long and French, 1967)and when these neutrons slam into particles having a similar mass as theirs(protons , H+) , they drastically slow down, making a "cloud" of "thermalized" neutrons.

As we already know that water is the primary wellspring of hydrogen in soil, the thickness of thermalized neutrons around the test is about corresponding to the division of water present in the soil. The arrangement of the test is as a long and limited chamber, comprising of a source and a finder. The estimations are taken in this test by bringing the test into an entrance tube, which is as of now presented in the soil.

One can decide soil amount of moisture in the soil at various profundities by balancing the test in the cylinder at various profundities. The moisture substance is gotten with the assistance of this gadget dependent on a direct alignmen t between the check pace ofthermalized neutrons read from the test, and the soil moisture substance got from adjacent field tests.

The installation of sensors plays an important role in the efficient implementation of irrigation robotics. One can use a single sensor to control the irrigation of multiple zones in the fields. And one can also set multiple sensors to irrigate individual zones. In the first case where one sensor is utilized for irrigating multiple zones, the sensor is places in the zone which is the driest of all or we can say the zone which requires maximum irrigation in order to ensure adequate irrigation in the whole field. The placement of the sensors should be in the root zone of the crops (ensuring that there are no air gaps around the sensor) from where the crops extract water.

This will ensure the adequate supply of water to the crops. Later, we need to connect the SMS controller with the sensor. The controller will control the working after the sensor responds. After making this connection the soil water threshold needs to be selected. Then water is applied to the area where the sensor is buried and it is left as it is for a day.

The water content now is the threshold for the sensor for scheduled irrigation as described earlier. After fetching the data through the sensors the microcontrollers come into work. It is the major component of the entire automated irrigation process. The whole circuit is supplied with power up to 5V with the help of transformer, a bridge rectifier circuit (which is a part of electronic power supplies which rectifies AC input to DC output) and voltage regulator.

Then the microcontroller is programmed. The microcontroller receives the signals from the sensors. The OPAMP acts as an interface between the sensors and the microcontroller for transferring the sensed soil conditions. The irrigator pumps thus operates on the information of the soil properties at run time (Figure 1).The irrigation process can therefore be automated with the help of moisture sensors and microcontrollers (Rajpal et.al, 2011).

Weeding:

Zimdahl (2010) in his report on “A History of Weed Science in the United States” stated about Thomas K. Pavlychenko , a pioneer weed experimentalist, who did a study on the competition among plants. After his detailed research on the same, he came concluded that the competition among the plants for water begins when their roots in the soil overlap to absorb water and nutrients and weeds were the strongest competitors for water.

The water requirement for the aerial parts of the plant is the number of pounds of water used to produce a pound of dry matter. The wild mustard plant (Brassica kaber var. pinnatifida) requires four times as much water as a well - developed oat plant, and the common ragweed plant (Ambrosia artemisiifol ia) requires three times as much water as a corn plant to reach maturity .One can calculate the water requirement per acre is determined by multiplying the production of the plant in pounds of dry matter per acre times the plant's water requirement.

Light is also an essential component for the growth of the plants. Weeds which grow tall, generally blocks the way of light to the plants. Sometimes weeds like green foxtail and redroot pigweed are intolerant of shade but may times weeds like field bindweed, common milkweed spotted spuroe, and Arkansas rose are shade tolerant. According to a study by researchers of the Indian Council for Agricultural Research, the country India, loses agricultural produce worth over $11 billion — more than the Centre’s budgetary allocation for agriculture for 2017 -18 annually due to weeds.

So to remove these weeds from the fields is of great importance otherwise it will not only occupy the land space but will also adversely affect the growth of other plants. Lie Tang et al. (2000), brought up a vision based weed detection technology in natural lighting. It was created utilizing hereditary calculation distinguishing a locale in Hue -Saturation -Intensity (HSI) shading space (GAHSI) for open air field weed detecting.

It utilizes outrageous conditions like radiant and shady and these lightning conditions were mosaicked to discover the likelihood of utilizing GAHSI to find the locale or zones in the field in shading space when these two boundaries are displayed at the same time. They came about given by the GAHSI gave proof to the presence and severability of such a locale. The GAHSI execution was estimated by contrasting the GAHSI-portioned picture and a comparing hand sectioned reference picture.

In this, the GAHSI achieved equivalent performance. Before developing a weed control automated system we need to differentiate between the crop seedlings and the weeds. A method was applied for recognition of carrot seedlings from those of ryegrass. Aitkenhead et al., (2003) implemented this method by the simple morphological characteristic measurement of leaf shape. This method has varying effectiveness mostly between 52 and 75% for discriminating between the plants and weeds, by determining the variation in size of the leaf. Another method for weeding was implemented using digital imaging.

This idea involved a self-organizing neural network. But this method did not give appropriate results which were expected for commercial purposes, it was found that a NN based technology already existed which allows one to find the differences between species with an accuracy exceeding 75%. In the contemporary world many automated systems are developed but earlier various physical methods were used which relied on the physical interaction with the weeds . Nørremark and Griepentrog (2004) proposed that weeding depends on the position and the number of weeds. Classical spring or duck foot tines were used to perform intra row weeding by breaking the soil and the interface of roots by tillage and thus promote the witling of the weeds. But this is not advisable method as tillage can destruct the interface between the crop and the soil.

Thus, further no contact methods like the laser treatments (Heisel 2001) and micro spraying, which do not affect the contact between the roots and the soil was developed. Nakai and Yamada (2014) explained the method of the use of agricultural robots for the suppression of weeds and developing methods of controlling the postures of robots in case of uneven fields in the rice cultivation. It used the method of Laser Range Fielder (LRF) for suppressing the weeds and controlling robot's posture. Åstrand and Baerveldt (2002) presented a robotic weed control system.

The robot was embedded with different vision systems. One was the gray - level vision which was used in developing a row structure in order to guide the robot along the rows and the other vision was color-based based which was most important and used to differentiate a single amongst the weeds. The row recognition system was developed with a novel algorithm with an accuracy of ±2 cm.

The first trial of this system was implemented in a greenhouse for weed control within a row of crops. The same technology was mentioned in the research done by Fennimore et al. (2017). The vision based technologies which were used to guide the robots along the row structure to remove weeds and to differentiate the single crop amongst the weed plants. The various weeding systems are:

Chemical based: In this technology, the system consisted of 8 nozzles at the back which were used for spraying herbicides. The whole system divided the images captured in 8 X 18 small rectangles or we can say blocks, each of these blocks covered an area of 8128 square mm. Later, each row which consisted of these blocks corresponding to number of nozzles was examined and processed one after the other. After examining the blocks, each box containing weeds are sprayed. On can also divide the images into 16 X 40 blocks, in this case each blocks cover s an area of approximately 8768 square mm. Thus, in this case we need 16 nozzles instead of 8.

The further processing, that is, the task of spraying was done on the basis of the conditions mentioned. The conditions are:

1 If the block examined consisting o f weed pixels exceeding 10% of the total area of the block, then it is categorized into a weed block.

2 All the blocks examined are sprayed with herbicides.

3 Then after these two conditions, the weeds whose area equal to or more than 30% is sprayed are supposed to be destroyed.

4 The herbicide which is sprayed in this method is a selective herbicide, which destroys only the weeds and not the other plants. The first two conditions mentioned above defines the where the herbicides are to be sprayed, that is, defines the areas which requires spraying. The first condition mentioned reduces the areas which contains very small amount of weeds and which does not require spraying. This is an important part of weeding.

To destroy weeds, all the parts of the weeds does not require spraying , but only spraying enough areas is important as when spraying is done on one part of weeds it is absorbed by different parts of the weeds ultimately destroying the weeds. But one needs to take care that enough areas in a weed are sprayed because if the sprayed areas are too small then, in that case the weeds may not destroy. Thus we define a minimum spraying area in the condition 3.The defined condition

4 is there to calculate the reduction in the amount of herbicides used as compared with the spraying in the overall area.

The evaluation of this weeding method requires the calculation of the destroyed weed rate, the correct spray rate, the false spray rate and the herbicide reduction rate. The following data is to be calculated as follows: Destroyed weed rate = (N K / N W) × 100 Correct spray rate = (NCSR /NSNWB) × 100 False spray rate = (NFSB / NSB) × 100 Herbicide reduction rate = (1 − NSB /N B) × 100 Here N K is the number of weeds killed, N W is the total number of weeds in the block, NCSB is the number of sprayed weed blocks, NFSB is the number of sprayed non -weed blocks, NSB is the total number of sprayed blocks and N B is the total number of blocks examined.

Pulse high voltage discharge method:

There is an increase in the desire to implement non -chemical weeding methods as the pressure to reduce chemical costs on the environment and farming increases (Giles and Davis, 1996) . The interest in organic farming has also led to the rise in interest of non -chemical weed management. (Bond and Grundy, 2001). Non-chemical weed control methods were studied (Parish, 1990) and include mechanical, electrical, and biological methods. The pulse high voltage discharge method is one such non - chemical weed control method that was implemented mainly to destroy small weeds.

These small weeds (of an approximate size of about 5 cm tall and stem diameter of about 2mm) can be destroyed with just one spark with energy of 153mJ and a 15 kV. Whereas the larg e weeds large weeds (which vary in size from about 80 cm to 120 cm tall and a stem diameter of about 10 -15 mm) can be destroyed with a charge of 20Hz.

Because of these spark charges, the stem and the roots of the weeds gets adversely affected, thus leading to a disruption in the transportation of waiter to the various parts of the weeds. Thus, the weeds wilt within a few days after the spark. In this weeding method, spark discharging devices are set up on the system in place of the nozzles in the previous chemical based method. Here the system is designed to apply spark only on the areas where weeds are detected.

Once the sites having weeds are detected, the selection of weed points is done by the system for spark discharge, these weed points represent the weed areas. Like the above discussed chemical method, in this method also some conditions are defined.

The conditions are as follows:

1 The average of all the coordinates of the pixels in the images are calculated and it is defined as the center of that region.

2 The spark discharge applied for weeding is applied at this center.

3 If a weed receives the spark discharge, then that particular weed is considered as destroyed. The first two conditions are established in order to select the spar discharging point s in the fields and the third condition is for setting the potential of weed destruction.

In this method some more factors are evaluated along with the three factors calculated in the previous method, the correct spark rate and the false spark rate. Correct spark rate = (NCSK /NSK)× 100 False spark rate = (NFSK / NSK) × 100 Here NCSK is the number of sparked weed pixels, NFSK is the number of sparked non -weed pixels and NSK is the total number of sparked points.

Drones in Agriculture Unmanned aeronautical vehicles (UAVs) or unmanned ethereal frameworks (UAS), otherwise called automatons, in a mechanical setting are unmanned aircrafts that can be remotely controlled. They work in confluence with the GPS and others sensors mounted on them. Drones are being implemented in agriculture for crop health monitoring, irrigation equipment monitoring, weed identification, herd and wildlife monitoring, and disaster management (Veroustraete, 2015, Ahirwar et. al, 2019, Natu and Kulkarni, 2016).

Remote Sensing with the use of UAVs for image capturing, processing, and analysis is making a huge impact on agriculture. (Abdullahi et. Al ,2015). The rural business appears to have grasped ramble innovation with great enthusiasm, utilizing these propelled instruments to change current agricultural methods. The complete addressable estimation of automation fueled arrangements in every single relevant industry is critical – more than USD 127 billion, as indicated by an ongoing PwC analysis.

They can be contrasted with a normal simple to use camera for unmistakable pictures, yet while a standard camera can give some data about plant development, inclusion and different things, a multispectral sensor extends the utility of the procedure and enables farmers to see things that can't be found in the noticeable range, for example, moisture content in the soil, plant health monitoring.

These could help defeat the different restrictions that obstruct agrarian production. (Shivanshu and Kandaswami , 2017). The development of the UAS is incorporated with Wireless Sensor Networks (WSN). The data recovered by the WSN enables the UAS to advance their utilization. For instance to restrict its splashing of synthetic compounds to carefully assigned regions. Since there are abrupt and continuous changes in ecological conditions the control circle must almost certainly respond as fast as could reasonably be expected. The reconciliation with WSN can help toward that path (Costa , F.G. et al., 2012). In precision agriculture, UAVs are maily applicable for agriculture operations such as soil and field analysis (Permicerio et al., 2012), crop monitoring (Bendig et al., 2012) , crop height Estimations(Anthony et al.,2014), pesticide Spraying (Huang et al., 2014).

However, their hardware implementations (Maurya, 2015) are purely adherent on critical aspects like weight, range of flight, payload, configuration and their costs. A research involving technologies, methods, systems and limitations of UAVs are examined (Huang et al., 2013) . About more than 250 models are analyzed as well as summarized in order to choose an appropriate UAV in agriculture. (S.R.Kurkute et al., 2016).

The agricultural drone market is expected to gro w over 38% in coming years. It is believed that the need for efficient agriculture is only going to become more important due to increasing population levels and changing climate patterns.

Crop Spraying

The UAV S , otherwise called drones, are chiefly established on the innovations of sensors and microcontrollers which are grown especially with an expectation to make up for the nonattendance of the pilot and accordingly empower the trip of unmanned vehicles and their independent conduct.

These drones have been utilized as substance sprayers by farmers since numerous years now and they are considered as effective and of great importance in the situations of cloudy climate and has also solved the problem of inaccessibility to a field of tall crops, for example, maize (Sugiura et al., 2005; Simelli and Tsagaris , 2017).

Additionally, they are likewise accepted to have a solid favorable position contrasted with satellite an airborne sensors of high picture resolution (Jannoura et al., 2015; Simelli and Tsagaris, 2017).D.K.Giles et al., 1987 retrofitted an air-carrier plantation sprayer with a microcomputer based sprayer control framework.

A foliage volume estimation framework, in view of ultrasonic range transducers was interfaced to a PC which controlled the 3 -nozzle manifolds on each side of the sprayer by the utilization of control calculations dependent on the amount of spray deposited. Kale et al., (2015) utilized drones for spraying synthetic substances on the yield where the drones are joined to actualize a control circle for horticulture applications.

These drones were implemented with sensors conveyed on the crops in the field known as remote sensor networks (WSN) which controlled the way towards applying the synthetic compounds. The data recovered by these remote sensors limited drones to spray the synthetic substances only into the assigned regions. Huang et al., 2015 built up a low volume sprayer for an unmanned helicopter. The helicopter utilized in this investigation has a principle rotor distance across of 3 m and a most extreme payload of 22.7 kg.

For like 45 minutes one gallon of gas was involved. This technique and the systematic outcomes from this methodology gives a precursor that could be utilized in creating UAV flying application frameworks for higher yields which has a higher target rate and bigger VMD droplet size. Xue et al., 2016 built up an unmanned airborne vehicle based programmed flying praying framework. The framework utilized a profoundly coordinated and ultra -low power MSP430 single-chip miniaturized scale PC with a free practical module.

This permitted course was programmed to coordinate the UAV for spraying at the required or the desired areas on the fields. The spray consistency for these UAV tests were better than the Standard Requirement for ultra - low volume spraying variety coefficient. Hang Zhy etal., 2010 developed a PWM Precision Spraying Controller for Unmanned Aerial Vehicles.

A UAV can be remotely controlled or automated by premodified flight plans. Therefore to this examination, PWM controller develops as a high exactness system for the spraying applications. Dongyan et al., 2015 assessed powerful swath width and bead circulation of aeronautical showering frameworks on M -18B and Thrush 510G planes. In this examination they assessed the powerful swath width and consistency of the droplet dispersion of two agrarian planes, M-18B and Thrush 510G, which flew at 5 m and 4 m tallness, individually.

The consequence of this examination expresses that the flight stature prompts the distinction in swath width for both the farming planes. The sprayer is the one which crumbles the sprayed liquid which is possibly a suspension, an emulsion or an answer into tiny drops and launch it with negligible power for circulating it appropriately. It is additionally in charge of the guideline of the measure of pesticide in order to maintain a strategic distance from extreme application. Intemperate use of pesticides may demonstrate inefficient or harmful to the dirt too the yield.

Likewise, the residue definitions of pesticides are disseminated with the assistance of dusters. Based on vitality required to atomize and to toss out the shower liquid, sprayers are arranged into four categories namely: The hydraulic energy sprayer, the gaseous energy sprayer, the centrifugal energy sprayer and the kinetic energy sprayer.

Hydraulic Energy Sprayer Journal Pre-proof Journal Pre-proof 27 In Hydraulic Energy Sprayer, the material to be sprayed is pressurized up to 40 - 1000psi in any of the two potential ways.

Either straightforwardly by utilizing a positive uprooting siphon or by utilizing a vacuum apparatus which will make the gaseous tension over the shower material noticeable all around tight holder. This pressurized material is shot out through the splash spout. Here, the siphon supplies the vitality which conveys the material to the plant foliage.

Water driven Sprayers produce a splash with most beads in the 200-400 micron width extend. As the beads framed are very little the structure a fog or haze which results in uniform inclusion and better contact with the bug or illness. In spite of the fact that, if the beads are little, they will in general vanish immediately when the mugginess is low and probably won't arrive at the objective.

A water driven sprayer contains the accompanying parts: tank, siphon with instigator, weight measure, controlling valve, help valve, control valves, funneling and spouts, control source and bolster outline.

Gaseous energy sprayer In Gaseous Energy Sprayer a blower produces a high speed air stream. This air stream is coordinated through the pipe toward the finish of which spray liquid will be available which will be permitted to be streamed by the activity of gravity through a diffuser plate. A fluid or residue is sustained into air stream to be conveyed to the objective.

Centrifugal energy sprayer The Centrifugal Energy Sprayer consists of a fast turning devise, for example, level, a concave or a convex plate, a wire mesh cage or a bucket, a puncture strainer or chamber or a brush. At the focal point of this gadget, the shower liquid is nourished under low weight which is additionally atomized by diffusive power as it leaves the outskirts of the atomizer.

Hydraulic Energy Sprayer

In Hydraulic Energy Sprayer, the material to be sprayed is pressurized up to 40 -1000psi in any of the two potential ways. Either straightforwardly by utilizing a positive uprooting siphon or by utilizing a vacuum apparatus which will make the gaseous tension over the shower material noticeable all around tight holder.

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Centrifugal energy sprayer

The Centrifugal Energy Sprayer consists of a fast turning devise, for example, level, a concave or a convex plate, a wire mesh cage or a bucket, a puncture strainer or chamber or a brush. At the focal point of this gadget, the shower liquid is nourished under low weight which is additionally atomized by diffusive power as it leaves the outskirts of the atomizer. The droplets are conveyed by the air stream created by the blower of the sprayer or by the common breeze, if the sprayer isn't furnished with a fan.

Kinetic energy sprayer

In Kinetic Energy Sprayer the spray liquid streams by gravity to a vibrating or swaying spout which delivers a coarse fan like spray design. This is explicitly utilized for the spraying of herbicides.

The spray effectiveness of any of the above utilized showers can be determined by utilizing the equation given underneath: Spray proficiency (%) = Minimum spray volume required X 100% The plant foliage which is tainted by a pest or weed or any other reason has to be sprayed. The region which is required to be sprayed differs with separation between th e lines of plants, separation between the plants in a similar line just as the development of the harvest. In addition, it is important to complete sprayer alignment practice before embraced real spraying work to guarantee uniform use of pesticides on the yields.

We can process the spraying volume by utilizing the formula: Application Rate in Liter per Acre or Hecter = (Constant figure 495 or 600 British Matric*Nozzle Discharge Rate in Liter every Minute)/ (Effective Swath Width in Feet or Meters*Spraying speed in Mile or Kilometer every hour) Pesticides are for the most part connected on the objective of the sprayed droplets which comprises of both, fine and coarse drops.

They are characterized in term of their distance across and thickness on the objective . In fact, now and again the objective leaf area which is required to be secured might be a lot more prominent than the ground region.

The Leaf Area Index (LAI) is the proportion of Leaf Area to Ground Area. LAI tents to shift with various yields and only from time to time surpasses around 6 -7.

Henceforth this is the reason behind per section of land requirement of water in a sprayer changing from harvest to yield contingent on the complete leaf territory to be secured. However numerous advances are being made in the sprayers which are to be utilized alongside the UAVs which gives high inclusion also is effective spraying.

Crop Monitoring

The advanced sensors and imaging capabilities have provided the farmers with many new ways to increase yields and reduce crop damage. Unmanned airplanes which are used for practical purposes in recent years have taken a bizarre flight.

New sensors mounted on UAV, with high - tech cameras being the eyes of the client on the ground and optimal procedures for survey, data acquisition and analysis are continuously developed and tested. As a matter of fact, the use of aerial surveys is not new to the agricultural world. Satellites have been used for a decade to inspect large croplands and forestry but a new level of precision and flexibility has been obtained with the use of UAVs.

To carry out UAV flights, one does not need to depend on the position of the satellite or having the correct weather conditions and as UAV pictures are taken 400 -500ft from the ground level; they result in better quality and provide precision. ER Hunt et al., (2005) evaluated Digital Photography from Model Aircraft for Remote Sensing of Crop Biomass and Nitrogen Status.

In their examination, they advanced an aerobatic model airplane for capturing images utilizing a buyer arranged computerized camera and the hued canvases were utilized to adjust the images. They watched huge contrasts in computerized number (DN) for a similar reflectance and that was a result of contrasts in the introduction settings chosen by the advanced camera. Further they utilized Normalized Green–Red Difference Index (NGRDI) and directly related it to the standardized contrast of the green and red reflectance's, individually.

The aftereffects of this investigation mirrored that for soybeans, horse feed and corn, dry biomass from zero to 120 g m−2 was straightly corresponded to NGRDI, however for biomass more noteworthy than 150 g m−2 in corn and soybean, NGRDI did not increment further. H. Sun et al., 2010, demonstrated the achievability of utilizing a continuous kinematic (RTK) worldwide situating framework (GPS) to consequently delineate area of transplanted column crops. They utilized a positive-situation vegetable harvest transplanter retrofitted with a RTK GPS recipient, plant, tendency, and odometry sensors, and an on -board ongoing information lumberjack for transplant mapping in the field during planting.

Field test outcomes demonstrated that the mean blunder between the plant map areas anticipated by the planting information and the over viewed areas in the wake of planting was 2 cm, with 95% of the anticipated plant areas being inside 5.1 cm of their real areas. Giovanna Sona et al., 2016, showed UAV multi spectral overview to guide soil and harvest for exactness cultivating applications. Multi spectral and multi temporal orthomosaics were delivered over a test field, which was a 100 m x 200 m plot inside a maize field, to delineate and soil files, just as yield statures, with reasonable ground goals.

A low cost multispectral imaging system was designed and developed for application to crop monitoring (de Oca et.al, 2018). It consists of a microcontroller along with two cameras embedded into the drone. One camera is sensitive to Infrared radiation while the other is a common RGB camera. This system provides images and information which are used by a software to compute the NDVI and subsequently the health status of a crop. Reinecke & Prinsloo, (2017) studied the benefits of drones in agriculture, and their limitations, illustrating from examples how drones operate on farms.

They discussed different features of deones and specifically how they assist farmers in maximizing their harvest by detecting problems early, and managing the crops by using specific cameras to detect pests and water shortages. (S. Nema et al,

2018) performed a detailed study on Spatial Crop Mapping and Accuracy Assessment Using Remote Sensing and GIS in Tawa Command. They did special crop mapping using satellite Landsat * data for Hoshangabad district of Madhya Pradesh and also carried out a Satellite data classification accuracy which resulted in overall accuracy as 87.60%.

Yield Mapping and Monitoring One of the key segments of the unprecedenting progressions in exactness cultivating frameworks, yield mapping, enables the farmer to see spatial variety over the field perceiving zone for future activities and outcome of the past sessions, management.

It alludes for the most part to the way towards gathering geo -referenced information on harvest yield and qualities, for example, showing in -field fluctuation, and the soil moisture content of the yield giving a benchmarking apparatus, when the yield is being harvested.

In combination with soil examining data, yield maps empowers the arrangement of variable compost maps which considers soil supplement levels just as the supplement which was expelled in the collected harvest. Last result of yield mapping is typically a tonal or shaded guide showing scopes of yield inside a field. Fundamental segments of grain yield mapping framework incorporate grain fow sensor (determines grain volume gathered), grain moisture content sensor (remunerates for grain moisture variability), GPS antenna (receives satellite sign), Yield screen show with a GPS receiver (geo -reference and records information), header position sensor (distinguishes estimations logged during turns), travel speed sensor (determines the separation the join goes during a specific logging interim).

Programming of the Software:

For yield mapping, there are basically 5 errands which are to be managed; information procurement, information preparing, LCD displaying < contact screen info and information sparing. The details of each one of them can be alluded: These 5 undertakings inside and out, structures in performing various tasks sometimes bring about clashes. Predominantly these contentions are identified with the time arrangement.

To conquer these contentions and to mull over every one of the undertakings we utilize four interfere with wellsprings of P80C592 in the framework, which are the clock intrude on source, the outer intrude on source, the ADC end -of-transformation intrude on source and the UART sequential I/O port intrude on source.

Yield Calculation and calibration:

Yield is characterized as harvest weight (lbs for cotton) or volume (bu for grains) reaped per unit region, which is in a roundabout way estimated by the yield sensor stream rate/(speed x swath width).

Yield stream rate is commonly determined each 1 – 2 seconds during collecting. The begin and end times for each line pass are balanced relying upon the measure of time the harvest takes to travel through sifting, isolating, and cleaning to the area of the yield sensor.

The deferrals for beginning of-pass and end-of-pass will rely upon the yield and speed of the consolidate. Scientific interjection systems have been utilized to expel commotion because of blunders and regular spikes in the crude sensor and area information (Searcy et al., 1989; Birrell et al., 1996).

Yield is by implication estimated as a mass power or volume estimation by the yield sensors. Presently the yield count needs to join an adjustment factor because of the way that the yield figuring that changes over to weight relies upon the harvest. To acquire an exact yield information a legitimate sensor alignment is imperative. Contrasting the scale loads of four with five burdens with the determined yield decides an alignment bend.

Yield sensors ought to be recalibrated as factors change, for example, dampness substance or half breed. However, utilizing the Yield Sense screen evacuates the requirement for recalibration after the underlying alignment toward the start of the period (Precision Planting).

Processing Yield Maps

With the utilization of a Geographic Information System (GIS) programming, the yield determined at each field area can be shown. The raw log document, contains focuses which are recorded during turns and as the grain move through a consolidate is a deferred process (unless ongoing amendment is connected), the sensor estimations neglect to compare to the careful gather areas.

To dispense with these conspicuous mistakes, the crude information is moved to make upfor the joining delay. Increasingly finished, the focuses which compare to the header up position are evacuated. Settings for grain stream postponement are join and some of the time even harvest explicit, yet run of the mill esteems for grain yields extend from around 10 to 12 seconds.

Typically a couple of focuses toward the start and toward the finish of a pass ought to be expelled too. These focuses are alluded to as begin and end-pass delays. Begin pass postponements happen when the grain stream has not balanced out in light of the fact that the lift is bit by bit topping off yet the consolidat e begins gathering the yield.

Thus, end -pass deferrals happen when the join moves out of the yield and grain stream progressively decreases to zero when the lift is totally exhausted. Moving of raw information to address for grain stream postponement and exclusion of focuses that speak to header status up and begin and end-pass deferrals is the essential information separating method incorporated with programming provided with yield mapping frameworks.

Challenges and future scope

Agriculture has been tackling significant difficulties like absence of irrigation system, change in temperature, density of groundwater, food scarcity and wastage and substantially more. The fate of cultivating depends to a great extent on reception of various cognitive solutions.

While large scale research is still in progress and some applications are already available in the market, the industry is still highly underserved. When it comes to handling realistic challenges faced by farmers and using autonomous decision making and predictive solutions to solve them, farming is still at a nascent stage.

In order to explore the enormous scope of AI in agriculture, applications need to be more robust. Only then will it be able to handle frequent changes in external conditions, facilitate real -time decision making and make use of appropriate framework/platform for collecting contextual data in an efficient manner.

Another important aspect is the exorbitant cost of different cognitive solutions available in the market for farming. The solutions need to become more affordable to ensure that the technology reaches the masses. An open source platform would make the solutions more affordable, resulting in rapid adoption and higher penetration among the farmers.

The technology will be useful in helping farmers in high yielding and having a better seasonal crop at regular interval. Many countries, including India, the farmers are dependent on monsoon for their cultivation. They mainly depend on the predictions from variou s departments over the weather conditions, especially for rain -fed cultivation. The AI technology will be useful to predict the weather and other conditions related to agriculture like land quality, groundwater, crop cycle, and pest attack, etc. The accurate projection or prediction with the help of the AI technology will reduce most of the concerns of the farmers. AI -driven sensors are very useful to extract important data related to agriculture.

The data will be useful in enhancing production. In agriculture, there is a huge scope for these sensors. Agriculture scientist can derive data like quality of the soil, weather and groundwater level, etc; these will be useful to improve the cultivation process.

AI empowered sensors can also be installed in the robotic harvesting equipment in order to get the data. It is speculated that AI -based advisories would be useful to increase production by 30 percent. The biggest challenge to farming is the crop damage due to any kind of disasters including the pest attack. Most of the time due to lack of the proper information farmers lose their crops.

In this cyber age, the technology would be useful for the farmers to protect their cultivation from any kind of attacks. AI -enabled image recognition will be useful in this direction. Many companies have implemented drones to monitor the production and to identify any kind of pest attacks.

Such activities have been successful many times, which gives the inspiration to have a system to monitor and protect crops. A robotic lens zooms in on the yellow flower of a tomato seedling. Images of the plant flow into an artificial intelligence algorithm that predicts precisely how long it will take for the blossom to become a ripe tomato ready for picking, packing, and the produce section of a grocery store.

The technology is being developed and researched at NatureFresh Farms, a 20 -year -old company growing vegetables on 185 acres between Ontario and Ohio. Knowing exactly how many tomatoes will be available to sell in the future makes the job of the sales team easier and directly benefits the bottom line, said Keith Bradley, IT Manager for NatureFresh Farms. It's only one example of AI transforming agriculture, an emerging trend that will help spur an agricultural revolution. From detecting pests to predicting what crops will deliver the best returns, artificial intelligence can help humanity confront one of its biggest challenges: feeding an additional 2 billion people by 2050, even as climate change disrupts growing seasons, turns arable land into deserts, and floods once-fertile deltas with seawater.

The United Nations estimates we will need to increase food production 50 percent by the middle of the century. Agricultural production tripled between 1960 and 2015 as the world's population grew from 3 billion people to 7 billion. While technology played a role in the form of pesticides, fertilizers, and machines, much of the gains can be attributed to simply plowing more land—cutting forests and diverting fresh water to fields, orchards, and rice paddies. We will have to be more resourceful this time around.

AI is likely to transform agriculture and the market in the next few years. The technology has been useful for the farmers to understand various types of hybrid cultivations which would yield them more income within the limited time frame. The proper implementation of AI in agriculture will help the cultivation process and to create an ambiance for the market. As per the data with leading institutions, there is a huge wastage of the food across the world and using the right algorithms, this problem can also be addressed which will not only save the time and money but it will lead to sustainable development.

There are better prospects for digital transformation in agriculture backed by leveraging technologies like AI. But, it all depends on the huge data which is quite difficult to gather because of the production process which happens once or twice in a year. However, the farmers cope up with changing scenario to bring digital transformation in the agriculture by implementing AI. It's only one example of AI transforming agriculture, an emerging trend that will help spur an agricultural revolution. We will have to be more resourceful this time around.

AI in Agriculture – Present Applications and Impact

Agriculture is both a major industry and foundation of the economy. In 2016, the estimated value added by the agricultural industry was estimated at just under 1 percent of the US GDP. The US Environmental Protection Agency (EPA) estimates that agriculture contributes roughly $330 billion in annual revenue to the economy.

Factors such as climate change, population growth and food security concerns have propelled the industry into seeking more innovative approaches to protecting and improving crop yield. As a result, AI is steadily emerging as part of the industry's technological evolution.

Applications of artificial intelligence to provide business leaders with an understanding of current and emerging trends, and present representative examples of popular applications.

Artificial Intelligence in the Agricultural Industry – Insights Up Front

Based on our research, the most popular applications of AI in agriculture appear to fall into three major categories:

- Agricultural Robots – Companies are developing and programming autonomous robots to handle essential agricultural tasks such as harvesting crops at a higher volume and faster pace than human laborers.
- Crop and Soil Monitoring – Companies are leveraging computer vision and deep-learning algorithms to process data captured by drones and/or software-based technology to monitor crop and soil health.
- Predictive Analytics – Machine learning models are being developed to track and predict various environmental impacts on crop yield such as weather changes.

In the full article below, we'll explore each category of AI applications in the agricultural industry, along with representative companies, use-cases, and videos. For further insights on the topic, we published an entire article on the current AI initiatives in agriculture in India.

Agricultural Robotics

Blue River Technology – Weed Control

The ability to control weeds is a top priority for farmers and an ongoing challenge as herbicide resistance becomes more commonplace. Today, an estimated 250 species of weeds have become resistance to herbicides. In a research study conducted by the Weed Science Society of America on the impact of uncontrolled weeds on corn and soybean crops, annual losses to farmers are estimated at $43 billion.

Companies are using automation and robotics to help farmers find more efficient ways to protect their crops from weeds. Blue River Technology has developed a robot called *See & Spray* which reportedly leverages computer vision to monitor and precisely spray weeds on cotton plants. Precision spraying can help prevent herbicide resistance. The short video below demonstrates how the robot works in action:

According to its website, the company claims that its precision technology eliminates 80 percent of the volume of chemicals normally sprayed on crops and can reduce herbicide expenditures by 90 percent. It has been estimated that over 1 billion pounds of pesticides are used in the US annually.

In September 2017, major manufacturing company John Deere announced its acquisition of Blue River Technology. John Deere is reportedly investing $305 million to complete the transition. The company claims that the original Blue Technology firm and current staff will remain in Sunnyvale where John Deere hopes to continuing growing the firm.

(Blue River Technology is one of many vendors listed in our robotics / vehicle vendor section here at Emerj.)

Harvest CROO Robotics – Crop Harvesting

Automation is also emerging in an effort to help address challenges in the labor force. The industry is projected to experience a 6 percent decline in agricultural workers from 2014 to 2024.

Harvest CROO Robotics has developed a robot to help strawberry farmers pick and pack their crops. Lack of laborers has reportedly led to millions of dollars of revenue losses in key farming regions such as California and Arizona. In the Hillsborough County, Florida region which has been described as the "nation's winter strawberry capital," between 10,000 and 11,000 acres of strawberries are typically harvested in a season.

Harvest CROO Robotics claims that its robot can harvest 8 acres in a single day and replace 30 human laborers. In the news clip video below features a demo of the Harvest CROO robot:

An estimated 40 percent of annual farm costs are funneled into "wages, salaries and contract labor expenses" for crops such as fruits and vegetables where labor needs tend to be the highest.

In June 2017, Florida-based Wish Farms announced its implementation of Harvest CROO Robotics' strawberry harvester in the summer of 2017. The farm claims that the robot spans "over six beds of plants" and carries "16 individual picking robots." To date, Harvest CROO Robotics has reportedly raised $2.8 million from investors and farms representing 20 percent of all U.S. strawberry production.

Crop and Soil Health Monitoring

PEAT – Machine Vision for Diagnosing Pests / Soil Defects

Deforestation and degradation of soil quality remain significant threats to food security and have a negative impact on the the economy. Domestically, the USDA has estimated that the annual cost of soil erosion is approximately $44 billion dollars.

Berlin-based agricultural tech startup PEAT, has developed a deep learning application called Plantix that reportedly identifies potential defects and nutrient deficiencies in soil.

Analysis is conducted by software algorithms which correlate particular foliage patterns with certain soil defects, plant pests and diseases.

The image recognition app identifies possible defects through images captured by the user's smartphone camera. Users are then provided with soil restoration techniques, tips and other possible solutions.

The company claims that its software can rapidly achieve pattern detection with an estimated accuracy of up to 95 percent.

PEAT recently published that its international clientele base had reached over 500,000. The company does acknowledge its partners, and client quotes on its website but specific case studies do not appear to be available.

Without specifics regarding the size of client farms, we are unable to confirm if the Plantix app poses any significant limitations for larger farms. Competitor CropDiagnosis appears to follow a similar model for its app.

Trace Genomics – Machine Learning for Diagnosing Soil Defects

Similar to the Plantix app, California-based Trace Genomics, provides soil analysis services to farmers. Lead investor Illumina helped develop the system which uses machine learning to provide clients with a sense of their soil's strengths and weaknesses. The emphasis is on preventing defective crops and optimizing the potential for healthy crop production.

According to the company's website, after submitting a sample of their soil to Trace Genomics, users reportedly receive an in-depth summary of their soils contents. Services are provided in packages which include a pathogen screening focused on bacteria and fungi as well as a comprehensive microbial evaluation.

As of February 2017, the company has raised $8 million in total equity funding from six firms including the Illumina Accelerator. Product packages begin at $199 for the Pathogen Screen. Favorable quotes from two farms are featured on the Trace Genomics website. However, data indicating how Trace Genomics specifically improved outcomes is not included

SkySquirrel Technologies Inc. – Drones and Computer Vision for Crop Analysis

The presence of drones in agriculture reportedly dates back to the 1980s for crop dusting in Japan. The market for drones in agriculture is projected to reach $480 million by 2027. Today, companies are leveraging AI and aerial technology to monitor crop health.

SkySquirrel Technologies Inc. is one of the companies bringing drone technology to vineyards. The company aims to help users improve their crop yield and to reduce costs. Users pre-program the drone's route and once deployed the device will leverage computer vision to record images which will be used for analysis.

Once the drone completes its route, users can transfer a USB drive from the drone to a computer and upload the captured data to a cloud drive. SkySquirrel uses algorithms to integrate and analyze the captured images and data to provide a detailed report on the health of the vineyard, specifically the condition of grapevine leaves. Since grapevine leaves are often telltales for grapevine diseases (such as molds and bacteria), reading the "health" of the leaves is often a good proxy for understanding the health of the plants and their fruit as a whole.

The SkySquirrel Technologies team provides an overview of how the drone functions in the short video demonstration below:

The company claims that its technology can scan a 50 acres in 24 minutes and provides data analysis with 95 percent accuracy. Specific use cases do not appear to be available on the company's website.

(Readers with a specific interest in drones may be interested in our full article called "5 Industrial Drone Applications".)

Predictive Analytics

aWhere – Satellites for Weather Prediction and Crop Sustainability

aWhere, a Colorado based company uses machine learning algorithms in connection with satellites to predict weather, analyze crop sustainability and evaluate farms for the presence of diseases and pests.

For example, daily weather predictions, are customized based on the needs of each client and and range from hyperlocal to global.

Types of clients mentioned on the company's website include farmers, crop consultants and researchers. We've covered AI for weather prediction earlier this year, but the video below gives a good idea of some of the fundamental technologies at play.

As shown in the 3 minute video below, the company claims to specialize in providing a high quality of data that is continuously updated at a rapid rate:

The company also claims that it provides its users with access to over a billion points of agronomic data on a daily basis. Data sources include temperature, precipitation, wind speed, and solar radiation, "along with comparisons to historic values for anywhere on the agricultural earth."

The company does not appear to provide any case studies on its website. Software application examples are featured in the company's blog but it is unclear how much clients have invested in aWhere's services and how those investments have impacted outcomes.

FarmShots – Satellites for Monitoring Crop Health and Sustainability

Based in Raleigh, North Carolina, FarmShots is another startup focused on analyzing agricultural data derived from images captured by satellites and drones. Specifically, the company aims to "detect diseases, pests, and poor plant nutrition on farms."

For example, the company claims that its software can inform users exactly where fertilizer is needed and can reduce the amount of fertilizer used by nearly 40 percent. The software is marketed for use across mobile devices.

The 40 second tutorial below demonstrates how to generate a report from captured data using FarmShots software:

In April 2017, FarmShots along with its associate partner, Planet, announced limited free access to its products for John Deere clients through June 2017. This collaboration offers another glimpse into John Deere's interests in expanding into the agricultural tech space. FarmShots does not appear to feature examples of specific clients or case studies on its website.

The Role of Artificial intelligence in Agriculture Sector

Artificial intelligence technology is supporting different sectors to boost productivity and efficiency. AI solutions are assisting to overcome the traditional challenges in every field. Likewise.

AI in agriculture is helping farmers to improve their efficiency and reduce environmental hostile impacts. The agriculture industry strongly and openly embraced AI into their practice to change the overall outcome. AI is shifting the way our food is produced where the agricultural sector's emissions have decreased by 20%. Adapting AI technology is helping to control and manage any uninvited natural condition.

Today, the majority of startups in agriculture are adapting AI-enabled approach to increase the efficiency of agricultural production. The Market study report stated that the global Artificial Intelligence (AI) in Agriculture market size is expected to reach 1550 million US$ by the end of 2025. Implementing AI-empowered approaches could detect diseases or climate changes sooner and respond smartly. The businesses in agriculture with the help of AI are processing the agricultural data to reduce the adverse outcomes.

Advantage of implementing AI in Agriculture

The use of Artificial intelligence in agriculture helps the farmers to understand the data insights such as temperature, precipitation, wind speed, and solar radiation. The data analysis of historic values, offers a better comparison of the desired outcomes. The best part of implementing AI in agriculture that it won't eliminate the jobs of human farmers rather it will improve their processes.

- AI provides more efficient ways to produce, harvest and sell essential crops.
- AI implementation emphasis on checking defective crops and improving the potential for healthy crop production.
- The growth in Artificial Intelligence technology has strengthened agro-based businesses to run more efficiently.
- AI is being used in applications such as automated machine adjustments for weather forecasting and disease or pest identification.
- Artificial intelligence can improve crop management practices thus, helping many tech businesses invest in algorithms that are becoming useful in agriculture.
- AI solutions have the potential to solve the challenges farmers face such as climate variation, an infestation of pests and weeds that reduces yields.

Impact of Artificial Intelligence in Agriculture

AI technology is rapidly rectifying the problems while recommending specific action that is required to overcome the problem. AI is efficient in monitoring the information to find solutions quickly. Let's see how AI is being used in agriculture to improve results with a minimal environmental cost. By implementing AI can identify a disease with 98% accuracy. Thus, AI helps farmers monitor the fruit and vegetable by adjusting the light to accelerate production.

Forecasted Weather data

AI in an advanced way is helping the farmer to remain updated with the data related to weather forecasting. The forecasted/ predicted data help farmers increase yields and profits without risking the crop. The analysis of the data generated helps the farmer to take the precaution by understanding and learning with AI. By implementing such practice helps to make a smart decision on time.

AI is changing IoT

Artificial intelligence unlocks the true potential of IoT by enabling networks and devices to learn from past decisions, predict future activity, and continuously improve performance and decision-making capabilities.

IoT has seen steady adopted across the business world over the past decade. Businesses have been built or optimized using IoT devices and their data capabilities, ushering in a new era of business and consumer technology. Now the next wave is upon us as advances in AI and machine learning unleash the possibilities of IoT devices utilizing “artificial intelligence of things,” or AIoT.

Consumers, businesses, economies, and industries that adopt and invest in AIoT can leverage its power and gain competitive advantages. IoT collects the data, and AI analyzes it to simulate smart behavior and support decision-making processes with minimal human intervention.

IoT needs AI

IoT allows devices to communicate with each other and act on those insights. These devices are only as good as the data they provide. To be useful for decision-making, the data needs to be collected, stored, processed, and analyzed.

[Also on InfoWorld: The best software development, cloud computing, data analytics, and machine learning products of 2022]

This creates a challenge for organizations. As IoT adoption increases, businesses are struggling to process the data efficiently and use it for real-world decision making and insights.

This is due to two problems: the cloud and data transport. The cloud can’t scale proportionately to handle all the data that comes from IoT devices, and transporting data from the IoT devices to the cloud is bandwidth-limited. No matter the size and sophistication of the communications network, the sheer volume of data collected by IoT devices leads to latency and congestion.

Several IoT applications rely on rapid, real-time decision-making such as autonomous cars. To be effective and safe, autonomous cars need to process data and make instantaneous decisions (just like a human being). They can't be limited by latency, unreliable connectivity, and low bandwidth.

Autonomous cars are far from the only IoT applications that rely on this rapid decision making. Manufacturing already incorporates IoT devices, and delays or latency could impact the processes or limit capabilities in the event of an emergency.

In security, biometrics are often used to restrict or allow access to specific areas. Without rapid data processing, there could be delays that impact speed and performance, not to mention the risks in emergent situations. These applications require ultra-low latency and high security. Hence the processing must be done at the edge. Transferring data to the cloud and back simply isn't viable.

Benefits of AIoT

Every day, IoT devices generate around one billion gigabytes of data. By 2025, the projection for IoT-connected devices globally is 42 billion. As the networks grow, the data does too.

As demands and expectations change, IoT is not enough. Data is increasing, creating more challenges than opportunities. The obstacles are limiting the insights and possibilities of all that data, but intelligent devices can change that and allow organizations to unlock the true potential of their organizational data.

With AI, IoT networks and devices can learn from past decisions, predict future activity, and continuously improve performance and decision-making capabilities. AI allows the devices to "think for themselves," interpreting data and making real-time decisions without the delays and congestion that occur from data transfers.

AIoT has a wide range of benefits for organizations and offers a powerful solution to intelligent automation.

Avoiding downtime

Some industries are hampered by downtime, such as the offshore oil and gas industry. Unexpected equipment breakdown can cost a fortune in downtime. To prevent that, AIoT can predict equipment failures in advance and schedule maintenance before the equipment experiences severe issues.

Increasing operational efficiency

AI processes the huge volumes of data coming into IoT devices and detects underlying patterns much more efficiently than humans can. AI with machine learning can enhance this capability by predicting the operational conditions and modifications necessary for improved outcomes.

Enabling new and improved products and services

Natural language processing is constantly improving, allowing devices and humans to communicate more effectively. AIoT can enhance new or existing products and services by allowing for better data processing and analytics.

Improved risk management

Risk management is necessary to adapt to a rapidly changing market landscape. AI with IoT can use data to predict risks and prioritize the ideal response, improving employee safety, mitigating cyber threats, and minimizing financial losses.

Key industrial applications for AIoT

AIoT is already revolutionizing many industries, including manufacturing, automotive, and retail. Here are some common applications for AIoT in different industries.

Manufacturing

Manufacturers have been leveraging IoT for equipment monitoring. Taking it a step further, AIoT combines the data insights from IoT devices with AI capabilities to offer predictive analysis. With AIoT, manufacturers can take a proactive role with warehouse inventory, maintenance, and production.

Robotics in manufacturing can significantly improve operations. Robots are enabled with implanted sensors for data transmission and AI, so they can continually learn from data and save time and reduce costs in the manufacturing process.

Sales and marketing

Retail analytics takes data points from cameras and sensors to track customer movements and predict their behaviors in a physical store, such as the time it takes to reach the checkout line. This can be used to suggest staffing levels and make cashiers more productive, improving overall customer satisfaction.

Major retailers can use AIoT solutions to grow sales through customer insights. Data such as mobile-based user behavior and proximity detection offer valuable insights to deliver personalized marketing campaigns to customers while they shop, increasing traffic in brick-and-mortar locations.

Automotive

AIoT has numerous applications in the automotive industry, including maintenance and recalls. AIoT can predict failing or defective parts, and can combine the data from recalls, warranties, and safety agencies to see which parts may need to be replaced and provide service checks to customers. Vehicles end up with a better reputation for reliability, and the manufacturer gains customer trust and loyalty.

One of the best-known, and possibly most exciting, applications for AIoT is autonomous vehicles. With AI enabling intelligence to IoT, autonomous vehicles can predict driver and pedestrian behavior in a multitude of circumstances to make driving safer and more efficient.

Healthcare

One of the prevailing goals of quality healthcare is extending it to all communities. Regardless of the size and sophistication of healthcare systems, physicians are under increasing time and workload pressures and spending less time with patients. The challenge to deliver high-quality healthcare against administrative burdens is intense.

Healthcare facilities also produce vast amounts of data and record high volumes of patient information, including imaging and test results. This information is valuable and necessary to quality patient care, but only if healthcare facilities can access it quickly to inform diagnostic and treatment decisions.

IoT combined with AI has numerous benefits for these hurdles, including improving diagnostic accuracy, enabling telemedicine and remote patient care, and reducing the administrative burden of tracking patient health in the facility. And perhaps most importantly, AIoT can identify critical patients faster than humans by processing patient information, ensuring that patients are triaged effectively.

Prepare for the future with AIoT

AI and IoT is the perfect marriage of capabilities. AI enhances IoT through smart decision making, and IoT facilitates AI capability through data exchange. Ultimately, the two combined will pave the way to a new era of solutions and experiences that transform businesses across numerous industries, creating new opportunities altogether.

Some of IoT applications

The Internet of Things (IoT) describes physical objects embedded with sensors and actuators that communicate with computing systems via wired or wireless networks—allowing the physical world to be digitally monitored or even controlled.

Does your house have a smart thermostat? Or do you wear a fitness tracker to help you stay physically active? If you do, you are part of the Internet of Things, or IoT. It's become embedded in our lives, as well as in the way organizations operate.

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IoT uses a variety of technologies to connect the digital and physical worlds. Physical objects are embedded with sensors—which can monitor things like temperature or motion, or really any change in environment—and actuators—which receive signals from sensors and then do something in response to those changes.

The sensors and actuators communicate via wired (for example, Ethernet) or wireless (for example, WiFi, cellular) networks with computing systems that can monitor or manage the health and actions of connected objects and machines.

The physical objects being monitored don't have to be manufactured—they can include objects in nature, as well as people and animals. While some organizations might view IoT more expansively, our definition excludes systems in which all the embedded sensors are used just to receive intentional human input, such as smartphone apps, which receive data input primarily through a touchscreen, or other networked computer software, in which the sensors consist of a standard keyboard and mouse.

The constant connectivity that IoT enables, combined with data and analytics, provides new opportunities for companies to innovate products and services, as well as to increase the efficiency of operations. Indeed, IoT has emerged as one of the most significant trends in the digital transformation of business and the economy since the 2010s.

Some of IoT application

Looking at IoT applications, which are sometimes described as use cases, can help ground the discussion about what IoT is. Broadly, IoT applications occur in one of nine settings.

1. *Human health.* Devices can be attached to or inserted inside the human body, including wearable or ingestible devices that monitor or maintain health and wellness, assist in managing diseases such as diabetes, and more.
2. *Home.* Homeowners can install devices such as home voice assistants, automated vacuums, or security systems.
3. *Retail environments.* Devices can be installed in stores, banks, restaurants, and arenas to facilitate self-checkout, extend in-store offers, or help optimize inventory.

4. *Offices.* IoT applications in offices could entail energy management or security for buildings.
5. *Standardized production environments.* In such settings, including manufacturing plants, hospitals, or farms, IoT applications often aim to gain operating efficiencies or optimize equipment use and inventory.
6. *Custom production environments.* In customized settings like those in mining, construction, or oil and gas exploration and production, IoT applications might be used in predictive maintenance or health and safety efforts.
7. *Vehicles.* IoT can help with condition-based maintenance, usage-based design, or presales analytics for cars and trucks, ships, airplanes, and trains.
8. *Cities.* IoT applications can be used for adaptive traffic control, smart meters, environmental monitoring, or managing resources.
9. *Outside.* In urban environments or other outdoor settings, such as railroad tracks, autonomous vehicles, or flight navigation, IoT applications could involve real-time routing, connected navigation, or shipment tracking.

Other real-world examples abound. IoT solutions are being used in myriad settings: in refrigerators, to help restaurants optimize their food-compliance processes; in fields, to track livestock; in offices, to track how many and how often meeting rooms are used; and beyond.

Learn more about our Digital McKinsey, Technology, Media & Telecommunications, and Advanced Electronics practices.

The economic impact of IoT

The potential value of IoT is large and growing. By 2030, we estimate it could amount to up to $12.5 trillion globally. That includes the value captured by consumers and customers of IoT products and services.

The potential economic value of IoT differs based on settings and usages, with factory settings and human health applications representing outsize shares of this total. Factory settings could generate $1.4 trillion to $3.3 trillion by 2030, or just over a quarter of the total value potential. IoT economic impact in human health settings could reach around 14 percent of the total estimated value.

Another way of looking at IoT's value is to explore use-case clusters (similar uses adapted to different settings). Some of the most common use cases account for a sizable share of IoT's potential economic value:

- operations optimization, which is basically making the various day-to-day management of assets and people more efficient (41 percent)
- health (15 percent)
- human productivity (15 percent)
- condition-based maintenance (12 percent)

Other clusters include sales enablement, energy management, autonomous vehicles (the fastest-growing cluster), and safety and security.

IoT platforms

To get value from IoT, it helps to have a platform to create and manage applications, to run analytics, and to store and secure your data. Essentially, these platforms do a lot of things in the background to make life easier and less expensive for developers, managers, and users—in much the same way as an operating system for a laptop. They handle issues like connecting and extracting data from many different endpoints, which might be in inconvenient locations with spotty connectivity.

If you are trying to choose an IoT platform, you'll need a good understanding of your company's IoT strategy. Here are five characteristics to consider when evaluating IoT platforms:

1. *Applications environment.* Here, you might examine questions like: Can the platform develop, test, and maintain multiple applications? Can it connect easily to the applications your company already uses, for example, for enterprise resource planning?
2. *Data management.* When weighing this element, it's helpful to understand if the platform can structure and join multiple unfamiliar data sets, for example.
3. *Ownership of cloud infrastructure.* Does the infrastructure provider own and operate its own data centers, or which public cloud provider does it use? (See "What is cloud computing?" for even more on this topic.)
4. *Security.* What commercial-grade authentication, encryption, and monitoring capability does the platform have, and are they distinctive?
5. *Edge processing and control.* Here, you could examine whether the platform can do edge analytics, without first bringing data into the cloud, or whether it can be easily configured to control local assets without human intervention.

IoT security

The billions of IoT devices in use have naturally created new vulnerabilities for companies. As more "things" get connected, the number of ways to attack them mushrooms. Pre-IoT, a large corporate network might have needed to account for 50,000 to 500,000 endpoints being vulnerable to attack, while the IoT may involve a network with millions or tens of millions of these endpoints. Promoting cybersecurity, therefore, is crucial in the IoT era.

It's important to address customer privacy concerns vis-à-vis connected devices. But managing IoT cybersecurity is also about protecting critical equipment, such as pacemakers or entire manufacturing plants—which, if attacked, could put your customers' health or your company's total production capability at risk.

Six recommendations or actions could help CEOs and other leaders tackling IoT cybersecurity:

- understand what IoT security will mean for your industry and business model
- set clear roles and responsibilities for IoT security in your supply chain
- hold strategic conversations with regulators and collaborate with other industry players
- view cybersecurity as a priority for the entire product life cycle, and develop skills to achieve it
- transform mindsets and skills rigorously
- create a point-of-contact system for external security researchers and implement a postbreach response plan

The Industrial Internet of Things (IIoT)

The Industrial Internet of Things, or IIoT, is among the advanced manufacturing technologies collectively referred to is Industry 4.0, or the Fourth Industrial Revolution.

What are some benefits of IIoT? It can drastically reduce downtime, open up new business models, and improve customer experience—and it can also make organizations more resilient. In the COVID-19 era, for example, digital management tools and constant connectivity allowed some companies to react to market changes swiftly and efficiently by quickly adjusting production capacity and simultaneously supporting remote operations.

Companies using IIoT for digital transformation in manufacturing can follow seven guideposts to align their business, organization, and technology spheres and help leaders successfully position their organizations to reap the full benefits from IIoT:

- Business
  - identify and prioritize use cases
  - focus on plant rollout and enablement
- Organization
  - keep an eye on change and performance management
  - build capabilities and embrace new ways of working
- Technology
  - attend to IIoT and data infrastructure, with a focus on core platform design, including IT/OT (information technology/operational technology) cybersecurity
  - choose an IIoT platform given the cloud imperative in manufacturing

- watch the tech ecosystem

Internet of Things B2B uses

Internet of Things B2B solutions account for the majority of economic value created from IoT to date. In B2B settings, for example, marrying IoT and AI can improve the predictive-maintenance capabilities of machines, while also empowering service providers to watch the health of their assets in real time, proactively addressing issues before a bigger breakdown occurs.

B2C applications have grown faster than expected, particularly given the adoption of home-automation solutions. However, through 2030, B2B applications are projected to nonetheless account for 62 to 65 percent of total IoT value.

The dynamics could affect IoT adoption

When it comes to getting more value from IoT, there are tailwinds as well as headwinds that will affect IoT adoption.

Three factors could accelerate the adoption of and impact from IoT solutions:

- *The perceived value proposition.* Customers see value in IoT, and the way it enables digital transformation and sustainability efforts—as evidenced by the $1.6 trillion in economic value generated from IoT solutions in 2020.
- *Technology.* Affordable technology, which enables IoT deployments at scale, exists for the vast majority of IoT applications. And progress in hardware can be coupled with developments in analytics, AI, and machine learning, which can enable more granular insights and faster decision making.
- *Networks.* These are the backbone of IoT, and higher-performing 4G and 5G networks are now available to more people.

Conversely, a variety of factors could constrain adoption. These include the need for change management (capturing value at scale will require collaboration across functions to encourage new behaviors), interoperability issues, and installation challenges, as well as concerns about cybersecurity and individual privacy.

If your organization is just getting started, it can be helpful to consider what could accelerate enterprise IoT journeys. An interview with Wienke Giezeman, a serial tech entrepreneur and initiator of The Things Network, offers insight on what can drive action: "We've seen this in the industry again and again—you cannot solve IoT problems with money. It's so tempting to try to solve these problems with cash, but really, it's the creativity and pushing for simplicity that leads to the solution, which shouldn't be so complicated."

The value in scaling IoT efforts

To really see the benefits of IoT, companies must embrace the technology at scale, instead of making one-off efforts. If your organization is adopting IoT, here are seven useful actions for scaling IoT:

- decide who owns IoT in the organization
- design for scale from the start
- don't dip your toe in the water—deploying multiple use cases can be a forcing mechanism in transforming operating models, workflows, and processes
- invest in technical talent
- change the entire organization, not just the IT function
- push for interoperability
- proactively shape your environment by building and controlling IoT ecosystems

IoT and AI In Agriculture Are Revolutionizing Farming

The importance of IoT and AI in agriculture cannot be sidelined. From ensuring healthier crops by monitoring yield-specific growing conditions and controlling costs due to excessive utilization of resources like water and electricity to forecasting crop prices and calculating the accurate yield per hectare — farmers are leveraging the two technologies in numerous ways. This article discusses how IoT and AI have given traditional farming a much needed modern facelift.

IoT and AI are rapidly redefining industrial processes across the globe. From wearable devices such as smartwatches and **AR/VR goggles** to smart energy grids and predictive maintenance sensors- together, IoT and AI have unleashed the power of data faster than ever.

There is no industry niche that has not started enjoying the benefits that IoT and AI have to offer. The agriculture sector is no exception.

These technologies have successfully revolutionized the agriculture industry in ways you cannot imagine — combating the most common problem the world is facing, i.e., bridging the gap between food demand and supply.

Certain challenges that farmers face on a daily basis

Today's world population stands at 7.3 billion and is **estimated by the UN** to reach 9.7 billion by 2050- that is a lot of mouths to feed.

The rise in the human population will invariably lead to an approximate **63% rise in agricultural** demand by 2050. But wait, there is hope. Technologically powered, advanced methods are helping farmers face the challenge by improving yield compared to traditional methods.

Moreover, traditional farming techniques are influenced by weather conditions, which have not favored humanity for a long time. For instance, climate change has led to an unfavorable rise in temperature and loss of humidity.

That leads to low production on the farm. On the other hand, deforestation is the reason behind soil erosion, leaving behind poor quality soil for farming. Pollution depletes air and soil quality affecting plant growth.

Nutrient deficient soil leads to poor yield and makes crops vulnerable to weed. Moreover, shortage of water and irregular irrigation causes stunted growth of crop plants. Farmers are in a fix, and they want a solution pronto.

Moving away from traditional farming techniques

There is no doubt that traditional farming methods are insufficient in meeting the constantly rising demand for food. The IoT and AI-driven technological evolution is allowing the agriculture industry to improve crop production and reduce wastage.

Connected farming solutions are enabling farmers to improve quality and boost quantity. Leveraging technology offers a faster go-to-market for crops. Learning these new techniques and implementing them may take a while, but the results are worth the effort.

IoT & AI in agriculture for smart farming

Simply put, smart farming is a high-tech and capital-intensive system which helps farmers grows food cleanly and sustainably. Agricultural drones, livestock monitoring solutions, and smart greenhouses are some of the IoT devices utilized in intelligent farming.

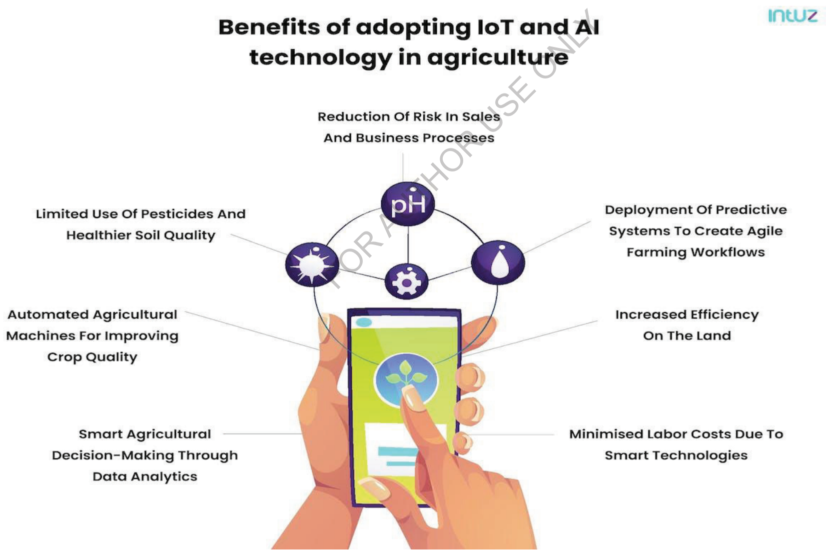
To meet the rising demand for more food and improve crop quality, farmers must adopt new technologies, and smart farming uses AI and IoT technologies to help farmers improve yield.

1. For starters, it ensures healthier crops by monitoring soil, temperature, humidity, and crop-specific growing conditions. Real-time updates through continuous observation ensure reduced crop wastage.
2. Farmers can use collected data to relieve their workload and automate a wide range of agriculture-related tasks.
3. The data collected can also be utilized to study trends. Data-driven forecasts help improve agri-business returns and improve the functioning of the food supply chain.

4. IoT smart applications also help control costs due to excessive utilization of resources like water and electricity. They can ensure timely irrigation and pest control from anywhere through connected devices and automatic systems.

Benefits of adopting IoT and AI technology in agriculture

Using AI and IoT systems will help farmers streamline traditional farming operations and enhance farm decision-making. If your agricultural business is looking to give its processes an upgrade, perhaps the two technologies can help:



1. Smart agricultural decision-making through data analytics

Big data and AI help farmers analyze vast quantities of data. **Cloud services** and edge computing can be used for studying and comparing data. It will allow them to decide the crop type and timing to sow.

They can also calculate the yield for a particular production pattern. There are many **use cases of big data** which help in monitoring weather-related data helps them make crucial decisions in time. Machine Learning helps detect pests and control diseases.

In the case of infestations, data analysis helps in implementing the best control procedures to minimize crop wastage. Moreover, it empowers farmers to forecast demand, estimate prices, and calculate yield- all of which are beneficial for fast-growing agricultural businesses.

2. Automated agricultural machines for improving crop quality

Farmers are using automation to handle farm monitoring activities. Robots, sensors, and drones keep track of growing conditions. They help in allocating resources for yield growth, identify crops ready for harvest, and destroy weeds. For example, you can place robots for planting focusing on a specific area that AI and computer vision, enabling a reduction of pesticides in the field and subsequently leading to the production of high-quality, edible food.

Automated agriculture machines also make farming sustainable by enhancing the quality of produce. For instance, autonomous tractors can be pre-programmed to give full autonomy to the farmer or controlled remotely. The tractor offers value to row crop farmers, reduces their manual efforts, and boosts their efficiency across operations.

3. Limited use of pesticides and healthier soil quality

AI product development, powered by ML, can help farmers analyze genetically modified seed information, the best time, and the number of seeds to be sown. In traditional agriculture, the use of fertilizer and pesticides is based on manual estimation.

Excessive watering and spraying of pest control chemicals deplete the nutritional value of the crop. Using aerial drones, farmers can regularly monitor crop conditions and control pesticides to grow cleaner and organic produce.

Wireless sensors in the farm help study soil quality to ensure improved crop traits to deliver high-quality products. Who knew farming could improve in such different ways

4. Reduction of risk in sales and business processes

Collecting data and analyzing will help farmers cover their business risks. They can estimate demand and forecast sales. Connected methods will also help them streamline business processes better than done manually. They can remotely control the batch to be stored or sold. They can calculate total costs to work out a profitable selling price for each crop.

5. Deployment of predictive systems to create agile farming workflows

Real-time monitoring through IoT technology improves the agility of agricultural processes. Prediction systems allow farmers to prepare for changes in growing conditions. The health of crops is adjudged against the weather, humidity, and air quality. Proactive measures to save the crops against infestation and bad weather ensure less wastage.

6. Increased efficiency on the land

The rising demand for food can only be met by producing more with the limited resources. AI-powered farming techniques ensure increased food production efficiency and potentially pave the way for environmentally friendly processes.

Automated watering and monitoring systems enable farmers to grow more crops by consuming less water and space than traditional methods. An intelligent irrigation system will allow them to decide when they should water the crops based on real-time data from the land. This is not possible in traditional agriculture.

7. Minimized labor costs due to smart technologies

It is tough and expensive to find skilled labor in the agriculture domain. Automating repetitive processes allows managing time and costs. IoT-enabled devices help farmers conduct regular checks and monitor plant health. Autonomous robotic machinery efficiently performs bulk harvesting, improving productivity and reducing labor costs, lightening the financial load on farmers.

Manual harvesting is time-consuming and leads to unnecessary wastage as well. Machine vision and AI-based robots detect mature fruits and crops and safely harvest them- even if the headcount on the field is low.

IoT and AI applications in agriculture: Changing landscapes

If you have read this far, you will agree that IoT and AI are the answer to increasing operational efficiency, reducing waste output, and meeting food demand. This section talks about various IoT and AI apps used in agriculture:

1. Precision farming systems

The most popular technique in AgriTech is precision farming. It includes services such as Variable Rate Irrigation (VRI) optimization, soil moisture probing, and cloud-based centralized water management. The technique uses sensors, autonomous machinery, and internet connectivity to maximize profitability by using water efficiently.

2. Agriculture drones

Ground-based and aerial drones are efficient in assessing crop health, monitoring infestation, and soil analysis. They are also used for crop spraying, sowing seeds, managing irrigation, and real-time field data collection. The collected data can be used to predict yield, nutrient measurement, and mapping of external factors.

3. Livestock monitoring and tracking solutions

Wireless IoT networks and connected devices can cut down labor costs on the ranch by monitoring cattle. IoT sensors can track the location of animals and even monitor their health. The farmers can quickly locate the animal on large farms and even prevent the spread of disease by separating unhealthy animals from the others- protecting the yield and bringing down livestock costs.

4. Smart greenhouses

Smart greenhouses leverage IoT to enhance yield by working on a proportional control mechanism. They use sensors to create a controlled environment for crops. The system is remotely monitored, and data is processed over cloud servers. Minimizing manual intervention, the smart greenhouse keeps a check on light, temperature, and humidity levels.

5. Real-time weather trackers

IoT-based smart sensors offer real-time climate conditions and weather updates. Farmers can use the detailed forecast to analyze crop requirements. Some systems also provide alarms to help farmers save their crops in case of extreme weather conditions.

6. Agricultural robots

Agricultural robots help cut down manual efforts and save time by performing multiple tasks on farms. They help monitor and harvest crops more efficiently than humans. They are trained through AI to detect and control weeds to maintain crop quality. These robots can sort the yield based on quality and pack them in less time than traditional methods.

7. Intelligent spraying hoses

AI-driven drones are useful in monitoring the vegetation index of the crops and their health. Their sensors keep check on insect infestation and diseases. These devices spray pesticides only on infected plants. This reduces the use of chemicals on otherwise healthy crops and controls the infection from spreading further.

8. Crop price forecast and yield prediction tools

Technologies such as AI, ML, and Big Data are being put together to help farmers predict yield from their crops. The historical data is analyzed to study price fluctuations, and a forecast of prices at the time of harvest can be calculated. Farm mapping helps in calculating the accurate yield per hectare. Farmers study different parameters such as rainfall, pesticides used, pH level, temperature, and other atmospheric conditions to arrive at a number.

9. Crop and soil monitoring sensors

Robots and drones with thermal or multispectral sensors monitor crop and soil health at all times. This helps in controlled irrigation and spraying of fertilizers. The sensors also read biome levels of soil to ensure high nutrient value in crops. AI also analyzes soil properties to suggest the best crop choices to maximize profitability.

10. Pest detection tools

AI systems are coupled with low-cost satellites to obtain images of the farm. These are compared with historical data to detect pests, insects, rodents, and diseases.AI algorithms match available data and alert farmers. In some cases, intelligent spraying is automatically initiated to avoid the spread of pests. Other precautions and pest control methods are also suggested to help farmers.

Agriculture technologies are here to stay

It is impossible to say that IoT and AI are not making any difference to the agricultural sector. In fact, farmers can work more efficiently and produce edible crops sustainably. The good news is the future of new tech agriculture is predicted to be much more systematic:

1. IoT device installation is expected to be around **225 million by 2024.**
2. Farms are expected to generate **4.1 million data points** in a day by 2050.
3. Revenue from Agricultural IoT is expected to grow at a CAGR of 22%.

The traditional knowledge and skills of farmers cannot be replaced by technology, but implementing AI and IoT reduces the chances of errors. Those with little understanding of farming can easily use these data-driven autonomous systems.

The Future of Agriculture using AI and IoT

Agriculture sector contributing a significant share in World economy and in more than nine counties agronomy is the leading segment. Population is rising immensely therefore quality and quantity of food demand increases enormously. Agriculture segment is providing employment prospects to large population as well. Conventional farming styles used by farmers are not competent to fulfil the enlarged demand. To meet the growing demands, emerging innovative practices need to be introduced which can be observed as Agricultural Intelligence and can brought agriculture 4.0 revolution.

Artificial Intelligence and Internet of Things like promising technologies convert traditional farming into smart agriculture by optimizing resources, reducing human labor, crop monitoring, weed handling, crop disease management, irrigation, harvesting and supply chain management. These technologies have proven for crop protection against climate changes, excess use of fertilizers, pesticides, herbicides and water for enhanced soil richness.

Agriculture industry plays an essential role in World economy. Thousand years back people have started working in farm and now it has been tremendously increased and contributing a lot in global trends. Population growth, protection from environment, climate change, rich quality and quantity of food required latest tools. This has given the new dimension to researchers, engineers, scientists and business holders in the area of agriculture. In a survey, it has been mentioned that by year 2050 global population will be approximately ten billion and hence land, water and other resources may be inadequate to endure demand supply chain. Therefore, cleverer method must be identified and implemented so that farm can be extra productive. In world, Intelligence is a crucial feature which differentiate human from anything. Artificial Intelligence is an approach which can be merged into any machine or computer to make them intelligent so that they can imitate humans and accomplished task. Future of agriculture can be viewed as integrating Artificial Intelligence, Big Data and Internet of Things into traditional agriculture process (Khanna and Kaur, 2019; Talaviya et al., 2020). Commonly used term is Smart Agriculture which is a revolution in Agriculture industry via which many local and global issues can be addressed. Use of modern technologies in Agriculture industry is to attain huge revenue by reducing the risk involved in crop failures and increasing the total harvest quality (Kim et al., 2008; Naganur et al., 2012). This drift is prospering along with increase of population, increasing food demand supply and urbanization. Bannerjee et al. (2018) proposed detailed of survey of Artificial Intelligence enabled technologies and machines because of which level of agriculture is elevated to higher level. Panpatte (2018) discussed that agricultural segment growth directly impacts the rural development and with technological support transformation can be view on world level. Jha et al. (2019) explains the role of Artificial Intelligence in various daily life applications. Automation in agriculture enhances the crop and soil monitoring, precision farming, harvesting and product commercialization. AI and IoT based smart technologies (Bashir and Sharma, 2012; Zadokar et al., 2017; Singh and Misra, 2017) with image processing have made a wonderful contribution for disease identification at initial level so enhances crop productivity. Agricultural Robots and Drones via computer vision are designed to perform various task like weed handling, seed sowing, disease detection and irrigation (Schor et al., 2016; Ahirwar et al., 2019). Savitha and Uma Maheswari (2018) demonstrated smart irrigation approach in agriculture field by using moisture and temperature sensors. In this study authors aim to explain the difficulties faced by farmers while doing farming via traditional approach. Use of AI and IoT has replaced traditional way of farming and serve the world to be at better place.

Current and Future of Agriculture

Agriculture is one of very significant economic sector in India because large percentage of population is dependent on agronomy. Approximately 60% of economy comes from agricultural sector but farmers face many challenges because of lack of technological awareness and implementation due to economic condition. Human labors are required at every stage which increases cost, increases time to complete task, increases probability of error and wastage which totally impact the crop quantity and quality. The lifecycle of Agriculture; the function of different parts is as follows:

♣ Soil Preparation: Preliminary stage of farming where farmers responsibility is soil preparation for seeds sowing. The process comprises of cleaning remains and making soil uniform, adding fertilizers etc.

♣ Spreading Seeds: Climate condition like weather, temperature, humidity, snow fall, rain fall etc. impacts a lot at this stage. Extra precautions need to be taken for distance between two seeds and depth for implanting seed

♣ Addition of Fertilizers: Nutritious and healthy crop is the prime requirement which entirely depends upon the soil productiveness. Therefore, soil fertility is the key factor and farmers tend to add fertilizers as per the requirements. Fertilizers contains nutrition required for plants like potassium, nitrogen and phosphorus, which provides supplement to farming field

♣ Irrigation: Soil must be moist and required humidity needs to be maintained. Quality of crop depends upon the appropriate amount of watering because overwatering or under watering may damage crops and sometimes hinder crops growth also

♣ Weed Safety: Undesired plants near to crop or at the boundary is known as weed and hence weed protection is very much required. Weed directly impact the crop quality. When weed quantity increases, it hinders the crop so that manufacture cost increases and lastly crop quality deteriorated

♣ Harvesting: Process of assembling ready crops from the farm is known as harvesting. Majority of workers are required for this task. Some of the post harvesting techniques are: Categorization, packing, preservation, cleaning etc.

♣ Storing: This is the post harvesting job where yields are stored in secured manner i.e., food product quality is kept intact. Sometimes packing and conveyance are also required for crops India is a land of numerous soil and varying weather condition. Agriculture is not a very promising sector for upcoming generation from carrier point of view. Major factors are unpredictable rain fall, less crop growth, ground water shortage, plant disease and commercialization of farms towards residential development.

The challenges faced by Farmers while doing farming in traditional means. Agriculture sector is in-fact in necessity of technological integration which minimizes human labor at every stage to make overall process smart. Evolution of agriculture yield depends upon weather, soil attributes, humidity, and environment temperature. Within past few years Machine Learning, Internet of Things, Cloud Computing, Wireless Sensor Networks have evolved a lot which contributes in monitoring and forecasting agricultural activities (Elijah et al., 2018; Liu et al., 2019). Agriculture management concept is the trend now based on recent technologies, provides decision making capability. 21st century farmers have smartphones so they have easy access of GPS, AI and IoT enabled techniques for remote monitoring, soil scanning, disease identification and treatment, sufficient watering and harvesting.

Power of AI and IoT on Agriculture:

Smart Farming Smart farming can be viewed as the future of agriculture. It is a promising idea which evolves farm management using most recent technologies such as Robotics, Drones, Internet of Things (IoT), Artificial Intelligence (AI) etc. and is discussed by Seem et al. (2022). The objective of smart farming is to optimize human labor along with other required resources and to increase quality and quantity of products. Advantages of integrating modern tools, farmers can easily supervise farm situation in distant mode and take strategic decisions. The summary of recent technologies available for farmers such as placing sensors in farm, using specialized software's, connectivity, location principles.

Data is the heart of IoT, which is efficiently drawn from things and which can be transmitted over internet. To make traditional farming smart, IoT devices need to be installed on land, from where they gather and process data in repetitive approach. Therefore, farmers are enabled for quicker response, decision making for promising issues along with dynamic environment condition.

♣ Examination: Sensors placed in farm send observed data from soil, crop, farm animals, environment etc.

♣ Diagnostics: Sensors recorded data feed to the IoT platform. It is executed with predefined models and rules. Diagnostic may be in the form of some object or land identification and any deficiencies or requirements

♣ Decision: When problems/issues are discovered then decision about required action need to be taken. Action may be performed by user or some machine and may be location dependent also

♣ Action: After estimation and accomplishment of end user the complete cycle repeats Agriculture industry is revolving around Artificial Intelligence enabled approach also to help farmers for crop quality, crop monitoring, pest control, soil monitoring, seed propagating, reducing human labor, optimize resources, harvesting, packaging, storing, a multitasking, optimum planting, nutrition management and food supply chain related things. Therefore, Artificial Intelligence and Internet of Things together can transform the conventional farming techniques into smart farming and hence Smart Agriculture can be viewed. The classification of AI and IoT based applications for Smart Agriculture.

A. Smart Monitoring

Artificial enabled IoT based smart systems contribute to preserve perfect conditions so that quality food products can be grown. In previous years, agriculture industries have been developed a lot in terms of monitoring.

Field Monitoring

To monitor farm field, variety of sensors are placed which keep sending acquired data to central process which uses some software's to analyze it. Alternatively Unmanned Aerial Vehicles (UAV) are now very popular in agriculture, is known as Agriculture Drones.

They contribute very effectively is smart agriculture as capable to collect data from farm for monitoring and analysis. Sometimes advanced features are integrated in drones and they can accomplish various tasks earlier performed by human labor like seed sowing, removing weed, crop planting, spraying, pest control, harvesting, packaging etc. Gondchawar and Kawitkar (2016) demonstrated GPS controlled Robot used for distant monitoring and field data control. Realized a real time smart decision system prototype for digital farming.

Depending upon the nature of data available, irrigation procedures, farm factors and weather circumstances, system automatically acquires conclusion rubrics (Cambra Baseca et al., 2019). Ahmed et al. (2018) demonstrated precision architecture and smart farming for rural areas with an objective to cover prolonged range using Internet of Things.

Environment Monitoring

Technology plays a critical role to understand and predict environment, Internet of Things is one of them. Environment monitoring is related to techniques offered to sense the environment with the help of sensors and getting real time statistics about soil, weather, air and water.

Data send by sensors are analyzed for the further farmer actions like changes in seed sowing plan, modification in harvesting, variation in irrigation schedule for crop quality improvement. Lai et al. (2019) demonstrated Kalman Filter (KL) algorithm for refining precise prediction and monitoring of air quality using IoT technology. Accuracy of 27% has been reflected in results and errors are declined by 68% with IoT application.

Harun at al. (2019) discussed how Brassica Chinensis is progressing in precise atmosphere when light parameters are varied. The relationship among atmosphere, light and plant geomorphology over IoT technology has been deliberated by authors. Lazarescu has demonstrated low cost WSN platform rich for extended term environment monitoring.

This design is suitable for IoT applications and have features like readily deployable, elongated life, reduced cost, less maintenance, reduced error, uninterrupted facility with superior quality of service (Lazarescu, 2013).

Cattle Monitoring

Agriculture sensors IoT based can be included and attached with the farm animals so that their well-being and act can be recorded. Livestock monitoring and following supports to acquire information about cattle health, location etc. These sensors even recognize and inform farmers about which cattle is sick or injured so that same can be detached from a group to avoid any further spread of infection. Large farm owners can use Drones for tracking the cattle and it reduces and sometimes eliminated the human labor involvement.

Crop Monitoring

Crop monitoring is related to the recognition and nursing the crop wellbeing, which can be undertaken by using AI enabled algorithms and IoT sensors or RFID chips. Important parameters monitored by sensors positioned in farm are: Soil characteristics, humidity, disease detection, animal disturbance, pest detection etc. Triantafyllou et al. (2019) demonstrated an application for saffron agriculture monitoring in Greece. Component organization for smart agricultural monitoring system using Internet of Things in support with energy saving protocols. Morais et al. (2019) demonstrated the data procurement procedures defined as my Sense environment. It is a four-level high-tech structure consist of sensor nodes, links, cloud facilities and provision for software applications of users. To improve the implementation of crop monitoring, technologies are integrated to achieve low cost, speedily deployable, highly accurate along with optimized resources.

Remote Sensing

It is used to procure information on the basis of electromagnetic radiation interaction. Instead of absorbed or emitted radiation, it considers the reflected radiation (Mulla, 2013). Furukawa et al. (2020) demonstrated that Unmanned Aerial Vehicles (UAV) are used for corn crop monitoring. Corn height estimation is carried out using 3D Photogrammetry technology. In the field of smart agriculture, remote sensing has found numerous application: • Crop production • Crop damage

- Crop progress
- Crop identification
- Cultivation
- Stress detection
- Prediction of expected crop
- Pests' identification
- Disease infestation
- Soil moisture assessment
- Irrigation monitoring
- Irrigation supervision
- Soil mapping
- Soil management
- Crop nutrition shortage recognition
- Flood mapping and monitoring

- Weather data acquisition
- Precision farming
- Climate change monitoring
- Crop quality analysis
- Land mapping
- Humidity estimation

Soil, Temperature etc. Monitoring

To grow crop in quality and quantity, every farmer must be aware about the suitable soil and surrounding temperature requirements. Soil may face numerous threats often such as corrosion, contamination, acidification, compaction, damage in organic material, biodiversity degradation etc. sometimes Soil characteristics like pH value, moisture, nutrition value may vary with time so IoT sensors and AI algorithms can identify/record changes and send data to farmers. Accordingly, farmers can take decision to prevent crop from threats, environment temperature variations and for use of nourishments as per the nature of crop. Hirsch et al. (2019) demonstrated a suitable IoT environment for monitoring temperature and soil humidity in farm as well as at home. Influence of environment on growth of plant has also deliberated in low power and upgradable architecture based on IoT.

Unauthorized Action Recognition

Illegal movements of humans and wild animals must be restricted in farm to protect crop. It is always very expensive to monitor large farm field via human labors, probability of error also increases here. With technological developments in Artificial Intelligence, Internet of Things etc., various security systems, alarms have been developed and effectively deployed in fields. Several methods are there to avoid intruder detection.

One is to place camera in field and when it detects any kind of motion or malicious activity, necessary action will be taken. Muminov et al. (2019) presented a computer-generated fencing application in farm to monitor and restrict goats' movement. Intelligent GPS collars are used and approximately 20% of goats have probability of getting electrical stimulus and it is only when goat is in threatening zone. Electrical stimulus is applied to goat depending upon the posture if they are neither stopped or returning in warning zone. Potamitis et al. (2019) demonstrated sensor based automatic device for trees surveillance on large farm land. It uses an accelerometer for insect investigations and this device continuously transmits short vibrations from inner portion of tree to server located at remote location. Author also presented the use of same device at global scale for other situation applications like prohibited tree cutting, restricted tree movement recognition, detection of wood pests in trees etc. **Motion Recognition**

Artificial Intelligence enabled approaches are very powerful in motion detection. Passive Infrared sensors located in fields detect movements in supervised areas. Researchers have presented and applied various techniques and tools. Liu et al. (2019) established and demonstrated modern system based on Internet of Things for agricultural land monitoring. Developed system is intelligent, low cast, durable, scalable, capability of motion detection and gather data as well as control equipment in distant mode.

Data Acquisition

Multimedia data capturing is essential to process and extract beneficial data from images, videos etc. and Artificial Intelligence supports to make overall process smarter. Physical environment of real time agricultural land can be simulated in adaptive scenario to extract image attributes required for particular applications. Kurihara et al. (2020) demonstrated the practical features of hyper spectral imaging system involving Unmanned Aerial Vehicles (UAV). This high-tech system is suitable for precision agriculture and managing forest using image processing.

B. Agrochemicals Applications

Researchers have listed about the yearly agricultural loss of approximately 20 to 40% of total production therefore some fertilizers or pesticides are required. Agrochemicals are the variety of chemicals used for agriculture, it may be manures, chemical fertilizers, insecticides, weed killers etc.

Sometimes the mixture of two or more materials are used to improve crop quality, controlling pest in farms, prevent disease and preserve the food for longer time duration. Perfect quantity of pesticides needs to be added else overuse may damage crop or harm the atmosphere and human wellbeing. AI algorithms and IoT sensors can sense soil attributes and help farmers to take necessary actions for minimizing waste and improving crop quality.

Weed Detection

Generally, weed is any unwanted plant grown in farm and farmers had to fight with it, weed impacts a lot on crop growth. Weed elimination is the major mission because it hinders various human actions. Integration of Artificial Intelligence, Image Processing and Internet of Things have developed promising means for precise real time weed recognition in farm ground.

Lottes et al. (2018) explains the weed recognition and classification for accurate farming. Image sequences segmentation is carried out by fully convolution networks in terms of pixels, soil parameters, crop attributes and weed nature. Potena et al. (2016) designed and demonstrated real time precise weed classifier which supports fast and exact crop development. It is accomplished by summarized training set with high accuracy where camera is located on agricultural robot. **Fertilization**

To grow the harvest and increase crops productivity, farmers used to add organic materials in land is known as Fertilizers. Basically, three plant nutrition's exist in fertilizers: Nitrogen, Phosphorous and Potassium.

Some other varieties of fertilizers are sometimes used by farmers are Calcium, Sulphur, Magnesium, Macronutrient type, inhibitors etc. Technology plays an important role to add on nutrients time to time or by recycling nutrients. Lavanya et al. (2020) demonstrated AI and IoT based intelligent system where sensors sense the data corresponding to the Nitrogen, Phosphorous and Potassium levels in soil. Sensors anticipate the colorimetric process by LDR and LED. Fuzzy rule-based system designed by researcher, analyses the information and instruct farmer to take necessary action.

Pesticides Application

Chemical materials which are used to kill insects are known as Pesticides, which is used by all farmers. Use of pesticides in agriculture may also damage the crop quality and quantity.

AI and IoT based system facilitate the farmers to unnecessary use of insecticides. Lee et al. (2017) describes an IoT based smart system which minimizes the pesticides usage in fruit trees. This system is also capable to predict the presence of pests in varying temperature and humidity environments.

Herbicides Applications

In agricultural field, Herbicides are used to control weeds density and endorse crop health. Mostly herbicides remain lively in atmosphere for longer duration and may cause water and soil contamination.

Sometimes the herbicide degradation residue may contribute toxic in atmosphere. Arakeri et al. (2017) demonstrated an intelligent system comprises of Machine Learning, Image Processing and Internet of Things. This robotic system is capable to categorize weed from crop using computer vision and apply appropriate quantity of herbicides.

Pest Control

One hazardous enemy of farmers is Pests, which may damage the crop quality if not treated on time. Artificial Intelligence has given a very effective approach to handle it. Acquired images are compared with reference image by AI algorithms.

Sensors gathers data automatically which identifies the presence of pests, impact of insect if any and even the kind of insect. Farmers can receive alerts, reports and monitor their farm from smartphones and hence farmers can get support to fight against pests.

Yue et al. (2018) anticipated and explains automated high-tech prototype for pest observation and detection using Laplacian pyramid technique. Results have shown the evidence of developed system performance.

Spraying Crop

Spraying is also recognized as crop dusting. In spraying process, the chemicals are diluted in water and then crop is covered with it so that pests must be killed.

With the advent of technology, Aircrafts, Unmanned Aerial Vehicles are used for spraying purpose which reduces time and cost involved in spay. Faiçal et al. (2014) describes UAV based model used for spraying in farm. Adaptive algorithm is used to compute UAV path in real time environment with dynamic wind strength and direction where wastage is also reduced.

C. Disease Management

In Agricultural farm crop quality and productivity increases if plant disease is controlled. Emerging technologies like AI, ML, IoT are effectively preferred for disease management to minimize losses and increase harvest.

Now a days many algorithms, applications, apps have been developed through which farmers can monitor their land and get notification on their smart phones.

Disease Prediction

Crop diseases may be in the form of bacteria, virus, pest, fungi, micro-organism etc., which may have harmful impact on animals or plants. Therefore, overall impact is on market scenario and production of agriculture products.

Khattab et al. (2019) demonstrated an intelligent IoT based monitoring structure for several plant disease at initial level. Monitoring system provides the information about favorable environment to grow crop optimum and forecast rate of disease spreading quickly.

Disease Detection

Precise and quick plant disease diagnosis plays very important role in agricultural products production and in minimizing crop quality loss. Traditional way of disease diagnosis is via visualization by human eye, through microscope, microbiological etc.

AI and IoT makes the process smarter, sensors help for automatic disease recognition in remote. Zhao et al. (2020) demonstrated such model with deep learning approach for visual features by taking thousands of samples. With such type of system crop disease identification accuracy is achieved up to 97.5.%

Disease Classification

Basically, plant illness is classified into two categories: Infectious and noninfectious. Infectious diseases are triggered by virus, protozoans, eukaryotes etc. while noninfectious disease is because of external atmospheric conditions.

Researchers have proposed many models based on deep learning algorithms for plant, leaf, animals' disease identification. Kale and Sonavane (2019) explains intelligent decision support system for agriculture using sensors. This model is applied to a large data base of plant disease as well as in real time scenario and it proves that classification efficiency is increased.

Disease Prevention

AI enabled and IoT based newly developed models can prevent disease so that it would not affect the agricultural production. Park and Park (2011) implemented greenhouse environment monitoring using wireless sensor networks. This model is also capable to avoid dew condensation on crop leaf so that crop production increases.

Soil Monitoring System

Quality of crop and its development entirely depends upon the kind of soil and its nourishment. Now a days soil quality is degrading as disforestation is growing. Plantix is an AI enabled application app developed by German which is based on image recognition.

It is capable to recognize the nutrition insufficiencies in soil. Therefore, farmers will get to know about use of fertilizers to recover crop quality and hence productivity increases. One more ML based company Trace Genomics is working in same domain and support farmers to do soil analysis.

Crop Well-Being Monitoring

Farmers have a responsibility to regularly monitor crop health to increase production. To perform this task manually, tremendous efforts need to be done. Technological inclusions made the system smarter.

SkySqurrel Technologies is a company which works on drone-based approach for crop health monitoring. Drone capture the images from farm and AI based algorithms analyzed these images and provides comprehensive report to farmers. On the basis of report farmers can take preventive measures in terms of pests, fertilizers or any other essential action. Kim et al. (2018) demonstrated IoT based system for predicting disease in strawberry.

This system collects the data from sensors, process it to the clous, analyze and forecast the details or precautionary measures. Pantazi et al. (2019) described an algorithm for feature analysis in image to recognize crop disease multiple crop classes. Multiple tests were conducted on plants where 95% of victory rate was achieved.

Livestock Well-Being Monitoring

Diseases of livestock can be recognized if regularly monitored, even their behaviors, feeding and actions can tell us about the problem they are suffering. Kumar and Hancke (2014) developed a Zigbee based prototype for cattle health monitoring. It is a low power, low cost, sensor based, small size, easily manageable, superior quality with great accuracy model.

D. Water Management

Water resource management in agriculture is essential for farmers in terms of crop growth, maintaining soil and particularly for sustainability. IoT technology makes it smarter and sometimes known as smart irrigation system or smart water management.

Sensors are used in farm, which senses and send required real time data through ICT and wise decision can be taken. This makes the overall system smart and efficient and hence cost involved is reduced, manual labor is not required, no monitoring is required, time involved is reduced while harvest quality is enhanced.

Smart Irrigation

Automation in irrigation or smart irrigation system is proficient in identifying the water requirement of each plant in farm. Traditional irrigation practice needs human intervention while smart irrigation is automatic and reduces human labor. Smart irrigation system reduces time, water, farmer efforts because various sensors placed in farm senses parameters like soil moisture, humidity, temperature etc.

On the basis of data received from sensors, decision about irrigation is to be taken whether to irrigate or not. Kamienski et al. (2019; Nawandar and Satpute, 2019) demonstrated IoT based model for smart irrigation with high precision. Overall process of water management is categorized into three parts: Water supply, water distribution and water consumption. Real time data acquisition, analysis about various trees or plants, soil attributes and environment conditions can be personalized by the users.

Weather Forecast

Propagating seed at precise time is a key factor for crop health. During the varying climatical circumstances, farmers need to find out the appropriate time for seed sowing during increased pollution environment. Along with it, schedule irrigation in agriculture farm is also very much required.

Artificial Intelligence based algorithms can investigate whether circumstances by using weather forecasting and water requirement in farm. It helps farmers to plan which crop is to grow and what is the appropriate time for seed propagating and watering. Goap et al. (2018) projected an intelligent automated prototype which uses sensors. It is efficient to predict soil humidity in forthcoming days depending upon weather forecast.

Rain Measurement

Farmers are totally dependent on rain for crop irrigation and rain gauge is a equipment used to measure rain rate. In the technological era, rain sensors are proficient to predict rainfall. Severino et al. (2018) proposed intelligent system consisting of sensor network.

This network capture soil humidity and dissolved pollutants concentration and proposed model predict the agricultural dynamics. Therefore, water irrigation can be optimized and even optimization can be applied different sectors of the same farm.

Humidity Monitoring

Humidity sensors can be used to quantity the humidity content in an air. Keswani et al. (2019) developed an IoT based wireless sensor network system with many sensors like: Humidity, light intensity, carbon di oxide, environment temperature and soil temperature to estimate amount of water needed for irrigation. The proposed system is adaptive and successfully predict values even in unfavorable weather conditions.

Soil Wetness Measurement

Estimation of soil wetness depends upon dryness level and extent of water extracted. Indirect methods are effectively used for such type of task. Angelopoulos et al. (2020) proposed an intelligent system for strawberry greenhouse irrigation.

Soil moisture sensors are placed in every container along with motor-controlled valve to avoid wastage of water. This type of model is efficient to eliminate old styled approaches of watering and water consumption.

Purification

Purification process is also known as desalination, which is advantageous for agriculture. This process segregates undesired salts from sea or salty water and eliminates ions, both are important for crop growth as fresh water is the boon of agriculture.

Two methods of purifications are there: Seawater Reverse Osmosis and Brackish Water Reverse Osmosis. Yaqub et al. (2019) demonstrated a hybrid purification plant which uses solar and wind energy. This type of system is extremely efficient even for industrial context which reduces operational cost and probability of error.

E. Smart Harvesting

Manufactures have developed various automated harvesting system for smart agriculture commercial purpose. Researchers have computed that automation in agriculture has reduced the harvesting cost approximately 40-45%, simultaneously large revenue is recovered from agroindustry.

Object Detection

Object detection is a kind of computer vision technique, this process depends on image processing. The objective of object detection in agriculture is to recognize and detect required objects in any image or video. It can be used to identify distinct objects, counting objects, separating some specific class of objects etc. Lin et al. (2020a) developed a technique for detecting types of fruits using Hough transform and shape matching. Results were observed on 450 natural atmosphere images and show that algorithm is efficient with fast convergence.

Obstacle Detection

Now a days many processes of agriculture are automated, no manual labor is involved there but sometimes obstacle may hinder the process. Therefore, obstacle detection is required and especially during the movements of autonomous vehicles in agricultural field.

Still a lot of research is need to be done for this, though path optimization, navigation, crop monitoring, irrigation, harvesting etc. have been explored a lot. Sometimes the outer agricultural environment is heterogeneous so deploying a security system is not feasible for autonomous vehicles.

Bac et al. (2013) proposed an obstacle plotting system for sweet-peeper for smooth movement of harvesting robot. In this approach soft and hard obstacles have been separated initially in dense environment and to robot manipulators are used to sweep obstacles sidelong.

Color and Shape Recognition

In case of vegetables or fruits, color and shape the possible the attractive attributes upon which agriculture depends. Product appearance is upon which product acceptability depends, acception or rejection and hence color appearances are crucial.

To perform such task in agriculture, artificial vision system of image processing is used, where some algorithms are applied for shape and color identification. Lin et al. (2020b) developed an algorithm for harvesting robot, which is capable to pick the fruits on the basis of three parameters: Color, depth and shape.

Classification and Recognition of Fruits

Efficient detection and precise recognition of fruits is a significant requirement in fruit harvesting system. Amalgamation of Artificial intelligence and image processing made the fruits segregation process automated in real time adaptive environment.

Wan and Goudos (2020) demonstrated smart real time robotic vision model for multiple class fruit detection, which uses region-based convolution neural network. Three types of fruits i.e. mango, apple and orange; have been recognized with an accuracy of more than 90%.

Robotics Arms

Harvesting is one promising field in agriculture where robots can make the process smarter with reduced cost, time, error. Barnett et al. (2020) examined the harvesting task partitioning by using multiple robot arms for kiwi fruit in shortest time interval. One more researcher applied and demonstrate robotic arm for tea leaf pulling. Action is taken on the basis of quantity required, sample image, visual movement etc.

F. Supply Chain Management

In the field of agriculture, Supply Chain Management (SCM) indicates handling association between production responsible for well-organized production and product supply from farm to consumers to meet their requirements with respect to availability, quality, quantity and cost. SCM is a five-pointer system:

Plan, source, make, transport and return. AI and IoT technologies have made the promising changes is supplying healthy food in structured manner.

Product Identification

Any agriculture yield may fall into one of the four categories: Fuel, food, raw material, fiber. In an industrial automation, RFID tags can be widely used to recognize, classify and managing product flow. Leng et al. (2019) explained IoT based agricultural product identification technique. RFID is used for supply chain scrutiny and this system shows efficient approach.

Traceability with Some Technology

Food safety is the major concern among all of us therefore traceability is the need which demand some recent technology also. Traceability is a type of risk managing tool which must have the capability to recognize food origin, food ingredients and sources.

It is very much required especially when food product is found faulty. In traceability scheme, any organization must keep record of every stage of food processing till distribution. Block chain technology can be effectively used in traceability, it is a distributed data structure which can be shared among all network members.

Artificial intelligence approach can be united with block chain and internet of things to attain safe smart agriculture. Caro et al. (2018) proposed a block chain based decentralized solution for traceability, applied for supply chain management. This system is transparent, unchallengeable and can also solve real time problems

Food Safety and Quality Assurance

Food safety of agricultural products is the prime responsibility as it directly impacts the health of individuals. Sahni et al. (2021) and discussed about food safety is a large domain which includes variety of processes, production in farm, food processing, food distribution, food storage, assortment and consumption.

Food industries maintain quality assurance, which is a set of actions to guarantee that developed food products meets defined conditions and standards. Internet of things technology contribute a lot in the food environment monitoring and surveillance of crop. It continuously shares the real time data among consumers and administrators.

Rajakumar et al. (2018) proposed an IoT based smart system to check contamination in milk. Different types of sensors like gas, temperature, humidity etc. are used in system to monitor and control food quality.

Chain Risk Control

It is the capability to recognize hazards instantly in food supply chain to guarantee advanced level of security for customers and manufacturers both. Wang and Yue (2017) demonstrated food protection system which tracks all required data during the entire supply chain.

This system alerts food manufacturers in case any hazard in food is being identified. This type of model can efficiently recognize safety dangers and precisely determine and raise the alert to expert.

Market Analysis

Agriculture market analysis is a large-scale approach which helps to create opportunities for farmers, manufacturers and business owners. From simple farmer to large super market, agriculture impacts the price, value, volume etc.

The objective is to deliver judicious and impartial market perception which help farmers to understand market trends, marketing strategy, product sale and product delivery.

Sun et al. (2019) proposed mobile crows sensing approach to improve existing agricultural data gathering arrangement. Farmers having smart phones will be able to receive immediately agricultural information from farm.

Agricultural Robots and Drones

Agriculture seems to be high-tech industry now because of the inclusion of innovative experts, firms and many more stakeholders. Technological development is quick and attractive to meet the food demands with automation and robotics. Agricultural Robots are dedicated to assist farmers in multiple tasks.

Robots can be programmed to examine, automate, repetitive and intensive kinds of tasks and hence the burden on farmers can be reduced (Schor et al., 2016; Arakeri et al., 2017). This increases overall production efficiency. Companies working in AI domain are developing Robots which are capable to accomplish multiple tasks in farms (Bac et al., 2013; Barnett et al., 2020).

Few important tasks performed by Robots in agriculture are shown in Fig. 6. These tasks are very much difficult to automate but Robot can perform these very effectively even in the presence of multiple obstacles. Using Drones also in

Agriculture sector is progressive and proven very effective supportable agricultural management.

Agriculture Drone is an Unmanned Aerial Vehicle (UAV) which helps in optimizing human labor, agriculture operations, crop monitoring, increasing crop quality and quantity (Faiçal et al., 2014). Product readiness process becomes very efficient with use of GPS, every step can be monitored which enhances efficiency and profit increases. Computer vision technology helps high resolution drones to get accurate information, crop fertility, disease identification and wastage reduction.

Conclusions

Agriculture is slowly becoming digital with AI showing promising potential in categories such as soil and crop monitoring, predictive analytics and robotics. Sensors and soil sampling to gather data are already in use to store farm management systems information for processing and analysis.

This data, algorithms, weather information and images from satellites are used to create AI based software for different agricultural regions in India. An open source platform would make the solutions more affordable, resulting in rapid adoption and higher penetration among the farmers. Though currently application of AI in agriculture is in a nascent stage but with time & capital investment, farm mapping, observation, predictability and on ground farm operations will be automated, leading to increase in efficiency and reduction in production cost and minimizing environmental impact.

AI-based technology can take over planting, maintaining, harvesting crops, grading fruits and vegetables and detect certain disease in plants. AI-powered solutions will not only enable farmers to do more with less, it will also improve quality and ensures faster go-to-market for crops.

AI-based technology can solve the problems that are present in agricultural sector leading to take agriculture in the era of e-agriculture or smart farming. Hence, this smart farming using AI-driven technologies can alter the future of Indian agriculture and can bring a paradigm shift in how we see farming today.

AI-driven technologies are emerging to help improve efficiency and to address challenges facing the industry including, crop yield, soil health and herbicide-resistance. Agricultural robots are poised to become a highly valued application of AI in this sector.

Evidence of wide adoption is apparent in the dairy farming where thousands of milking robots are already operating. This segment is anticipated to increase from a $1.9 billion to $8 billion industry by 2023.

It is feasible that agricultural robots will be developed to complete an increasing diverse array of tasks in the next three to five years.

Crop and soil monitoring technologies will also be important applications going forward as climate change continues to be researched and evaluated. One research study reported that climate change evaluated from 1980 to 2008 resulted in a 3.8 percent global reduction of maize and a 5.5 percent reduction of wheat.

The amount of data that can potentially be captured by technologies such as drones, and satellites on a daily basis will give agricultural business a new ability to predict changes and identify opportunities. We predict that satellite machine vision applications (for weather, crop health, predicting crop yield, etc) will become more and more commonplace for large industrial farms in the coming 5-10 years

It will be important that farmers are equipped with training that is up-to-date to ensure the technologies are used and continue to improve. This will help to prove the value of these tools over the long haul.

Additionally, extensive testing and validation of emerging AI applications in this sector will be critical as agriculture is impacted by environmental factors that cannot be controlled unlike other industries where risk is easier to model and predict. We anticipate that the agricultural industry will continue to see steady adoption of AI and will continue to monitor this trend.

The agricultural industry faces various challenges such as lack of effective irrigation systems, weeds, issues with plant monitoring due to crop height and extreme weather conditions. But the performance can be increased with the aid of technology and thus these problems can be solved.

It can be improved with different AI driven techniques like remote sensors for soil moisture content detection and automated irrigation with the help of GPS. The problem faced by farmers was that precision weeding techniques overcome the large amount of crops being lost during the weeding process.

Not only do these autonomous robots improve efficiency, they also reduce the need for unnecessary pesticides and herbicides.

Besides this, farmers can spray pesticides and herbicides effectively in their farms with the aid of drones, and plant monitoring is also no longer a burden. For starters, shortages of resources and jobs can be understood with the aid of man - made brain power in agribusiness issues. In conventional strategies huge amount of labor was required for getting crop characteristics like plant height, soil texture and content, in this manner manual testing occurred which was tedious. With the assistance of various systems examined, quick and non -damaging high throughput phenotyping would occur with the upside of adaptable and advantageous activity, on -request access to information and spatial goals.

Final thoughts

Today AI-powered technologies are used for solving several industries' purposes. AI is being utilized in sectors such as finance, transport, healthcare, and now in agriculture. AI is helping the farmers to monitor their crops without the need to invigilate personally into the farm. Many startups and enterprises are looking forward to AI development in agriculture.

AI is redefining the traditional pattern of agriculture. The future of AI in agriculture is way ahead in offering radical transformation with advanced approaches.

Global population is expected to reach more than nine billions by 2050 which will require an increase in agricultural production by 70% in order to fulfil the demand. Only about 10% of this increased production may come from unused lands and the rest should be fulfilled by current production intensification. In this context, the use of latest technological solutions to make farming more efficient remains one great necessity. Present strategies to intensify agricultural production require high energy inputs and market demands high quality food.

Robotics and autonomous systems (RAS) are set to transform global industries. These technologies will have great impact on large sectors of the economy with relatively low productivity such as agro-food (food production from the farm to the retail shelf). The UK agro-food chain generates over £108bn p.a., with 3.7m employees in a truly international industry yielding £20bn of exports in 2016.

Artificial Intelligence (AI) and Internet of Things (IoT) are very supportive to farmers to alter traditional way of farming into smart farming in growing population scenario. In conventional farming process, large number of human labors is required to carry out every task like nursing soil, monitoring crop, spraying pesticides and herbicides, weed handling, irrigation and harvesting.

Smart agriculture is meant for precise farming, better crop quality and quantity by optimizing agricultural resources via latest innovations. In this study authors have set the efforts to summarized literature review from quality research papers in orderly manner, available on modern technologies like AI, ML, IoT, Wireless Sensor Networks etc. Industries are working very hard for intelligent agricultural technological development through Robot, Drones, Unmanned Aerial Vehicles, machine automation etc. to improve efficiency and productivity.

In fact, Worldwide Government is also supporting research in the domain of agriculture by making some policies, funding agencies, rebate or allowance in investments, loan available. This study is an attempt to give a thought of mechanization in agriculture. Analysis of agricultural applications using Artificial Intelligence and Internet of Things has been presented.

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About Authors

Dr. Huda Lafta Majeed

Field Crop Department, College of Agriculture,

Wasit University, Iraq.

Email: hulafta@uowasit.edu.iq

Mobile: (+964)7702435901

Dr. Hussein Najm Abd Ali

Computer Engineering, Information Systems Technology

College of Education for Pure Science, Wasit University, Iraq

Email: Hanjim@uowasit.edu.iq

Mobile: (+964)7724988998

Bachelor's degree in Computer Engineering from Al-Mustansiriya University

Master's degree from Tambov State Technical University in Russia

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