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Smart Crops Monitoring Using New Computer Vision Iot System

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Abstract

Modern Agriculture is undergoing a significant transformation through Artificial Intelligence (AI) in Crop Management by aligning with sustainable goals and enhances resilience. Forecasting of crop outbreaks, Pest infestations and disease outbreaks, predicting extreme weather events empowers to farmers make real time data driven decisions that they will receive timely alert and recommendations improving productivity and less environmental impacts on crop with the help of predictive analysis of AI-driven tools for more accurate forecasting of crops. IOT based technologies like Smart Crop selection (SCS) is based on real time monitoring, predictive analytics, reduce input costs, site specific environmental and soil data, weather data.

Hydroponic methods of plants growing used water based, nutrient rich solutions and controls environment agriculture like optimize light exposure, protects crop from pests, (aquaculture, Nutri culture, drip system) crops with high quality. Depending upon crop cycle and scale hydroponic system used greenhouses which provided controlled environment for growing system of crops. Development of resilient crops related to abiotic stress, biotic stress and unpredictable climate change identified by the AI-driven tools, which is useful for increasing farming systems, enhance predictive models for increase food demands and integration with enhanced IOT. The goal to optimize inputs (water, pesticides, fertilizer) and maximum sustainability an advanced method of farming Precision agriculture techniques are used. This method uses technology to monitoring, measurement, analyze complex datasets for more accurate recommendations for variability in crops and fields.

Keywords

Artificial Intelligence, Data from crop, Smart Crop Selection (SCS), Hydroponic growing systems, Predictive models, crop-monitoring system.

INTRODUCTION

AI-driven tools and solutions used to improve crop monitoring, reduce environmental impact, security of food, pests' control, yield prediction transforming the area of agriculture. This AI agriculture revolution promoting the initiatives and involvement of government and private sector respectively.AI powered agriculture initiatives in India market are projected to grow from USD 1.7 billion in 2023 to 4.7 billion by 2028 like outcomes includes crop yield per acre 21% increment and reduced pesticides use by 9%. Traditional practices of Indian agriculture with precision driven methodologies empowering by AI. Leveraging AI for agriculture the Ministry of agriculture, digital ecosystem for farmers and financial services in private sectors promotes initiatives and innovation. By leveraging high-resolution satellite images, drone-based imaging, and ground-based sensors, farmers can make proactive decisions that minimize crop loss and maximize yields. Multispectral imaging helps in analyzing plant vigor by capturing data in multiple wave lengths. This allows for early detection of stress factors such as drought, disease, and nutrient imbalances.

The growing integration of IoT and AI in advanced crop monitoring systems, enabling precision agriculture, improved resource management, and enhanced crop yield. These systems leverage technologies like computer vision, satellite imagery, drones, pest risk, big data, soil data health and predict salinity risk (Sharma et al., 2020; Kumar et al.,). The combo of computer vision IOT and machine learning with acquirement of data sensors may undoubtedly assist reduce cost and increase production scale. Here's a more detailed look at the advancements:

Key Technologies and Applications:

- **Computer Vision and AI:**

Penn State researchers have developed a system that uses computer vision and AI to monitor plant growth in controlled environments, enabling continuous analysis of crop development.

- **IoT Sensors:**

IoT sensors are used for data analyzing, reduce waste, increases sustainability of crops, soil health, monitoring, predictions of real time conditions and fertilization.

- **Drones, Satellite Imagery:**

Images with high resolution is captured with help of satellite imagery and drones which is analyzed by AI algorithms to identify crop diseases, assess crop health and mapping of fields for precision farming.

- **Data Analytics and Predictive Models:**

Forecasting of big data analyze by the predictive models of AI, which is used to predict potential problems, and optimize resource allocation.

- **Automation:**

IoT and AI enable automation of tasks like irrigation, fertilization, and pest control, reducing labor costs and improving efficiency.

Benefits of Advanced Crop Monitoring Systems:

- **Increased Crop Yields**:

By optimizing resource use and addressing potential problems early, these systems can lead to significant increases in crop yields.

- **Reduced Resource Consumption:**

Method of farming precision agriculture plays crucial role for fertilizers, impact of environment, water used by the farmers, controls pest and reducing of waste.

- **Quality Improvement:**

Environmental factors and monitoring of data can lead to improved crop quality and nutritional value.

- **Enhanced Sustainability:**

By promoting efficient resource use and reducing environmental impact, these systems contribute to more sustainable agricultural practices.

- **Data-Based Decision Making**:

Real-time facts and powered analytics (AI)empower formed decisions for famers which is based on actual conditions, rather than relying on guess work.

Popularly, monitoring of crops by controlled environment agriculture hydroponic soilless systems is essential, reduce time required for methods of conventional crop monitoring and specific personnel methods which don't allow the fast collection of data to capture the dynamically plant growth with crop cycle. Continuous monitoring of the plants from early stage and to make crop more efficient, crop management allow by the automated crop monitoring system.

IOT Through Computer Vision

Combining with Computer vision use Internet of thing (IOT) enables continuity of monitoring data, analysis of plant growth, soil health throughout the crop cycle and adding new dimensions of systems which are interconnected reported by the researchers. IOT devices authorized camera, drones, robots for visual capturing of data, then visual data sent for the analysis over cloud storage using different techniques of computer vision which is image classification, object detection, facial recognition and tracking of motion and then exchange data over internet with help of embedded sensors which are linking devices.

Studies by the researchers show the Recursive Image segmentation model analysis real time data and refining predictions of data at each phase of the process, based on these results after monitoring of data it will indicates alerts and actions required then accurately change the tracking of plant growth.

The amount of water in the soil determines how much capacitance is there. The voltage level ranges from a minimum of 1.2V to a high of 3.0V, depending on the capacitance value. The main reason why capacitive soil moisture sensors are utilized is because their long service life is attributed to their ability to withstand corrosion. The resistivity and soil moisture are inversely correlated: conductivity is determined with help of quantity of water present in the soil. Because of its increased conductivity, more water in soil has less

resistance.

Traditionally a model CNN (Convolution Neural Network) based on machine learning helpful for the analysis of field and extract data from input images and make data highly effective for other tasks like object identification. In agriculture, smart farming used ICMD (Intelligent Control and Monitoring Devices) refers to monitoring (real data of soil health, crops), analyzing (CNN, Decision tree) and control (Pest control, fertilizer), utilize features of IOT for the field data over remote server within periodical manner. After that machine learning formulates the data which is reached to the server end.

Data will receive after extracts features with indexing of array, according to the strategy of server end learning strategy for model management, centralized training, heavy computations of devices, which proposed periodically and training of datasets, new testing of data record into it and alerts.

Fact Finders used a dataset of image of same field of crop, collection of data at regular intervals, which is known as satellite imagery used for plant growth conditions, soil health situation at random field locations. After that researcher combines their model of machine learning and data provided by the satellite data with field data for more productivity of estimated results from 2007-2024 (Anusha et al., 2019; Rao et al., 2019; Tenali et al.,2019). Researchers tested approach by monitoring the baby Bok choy which is Chinese cabbage is popular leafy vegetable, but fact finders said that it would work with different type of crops. More valuable automated precision agriculture for more than decade, different type of application like crop picking, pollination, heating, irrigation and spraying pesticides, autonomous weeding, tree pruning of devising robotic solutions for agriculture is used (Narendiran et al., 2018). In previous studies other purposes, machine vision system employed the advancement of technology the group developed.

With help of this study, growing of baby plants in soilless system isolated successfully, creating frequently images that will track the increased leaf coverage area of plant throughout their growth cycle. It is said by the researchers that recursive model uses previous outputs as future predictions, make performance robust and provides actual information of data monitoring of growth cycle of crop with help of installing sensors in model, collect then processed the data and developed the strategy for coding of data and worked with models of AI.

The project title," Advancing the sustainability of Indoor Urban Agriculture systems. "Initiative by Dr. Francesco Di Gioia, Associate professor of vegetable crop science and PI on overarching project, and stressed importance for the development of precision agriculture techniques, research was an in disciplinary project between agricultural plant scientists ang agricultural engineers, it is part of this project (Siddhartha et al.,2021; Lakkannavar et al.,2021) and (Ramkumar et al., 2021; G et al., 2021; M et al., 2021; Ayyadurai et al., 2021). An interdisciplinary approach suggested by Dr. Francesco is that increase important advanced efficiency, and controlled environment agriculture system with long term sustainability.

The capability to monitor automatically, data collection from field of crops, then appraise growth of plant and nutrient solution with monitored crop requirements, environmental factors like temperature, humidity, radiation- to bring in to use of IOT and AI technologies, is go through the way we manage crops," Di Gioia said "Our food and nutrition security will enhance by the controlled environmental agricultural systems with lack of inefficiencies and ambitious improving."

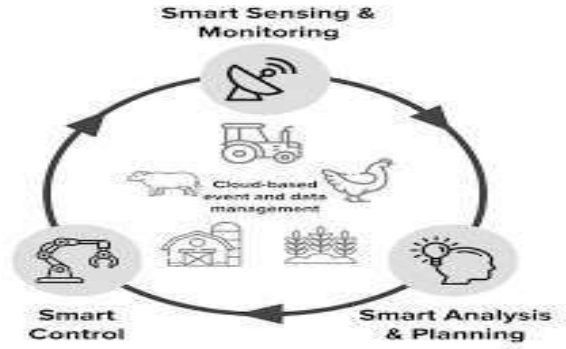

Figure1: Machine Vision System Based on Integrated Cloud

Based on AI and ML algorithms it will helpful for analyzing of large datasets from various resources like satellite imagery system, weather forecasting, soil testing sensors and records from crop data for arrange informed decisions for farmers .it will process the complex data to identify for monitoring, optimized plant growth, fertilizer and pest control, levels of irrigation with the use of these algorithms. Models based on machine learning plays crucial roles for the prediction of best time to harvest plant depend on weather forecasting and different situations of soil health (Marwa et al., 2020; Othman et al., 2020; Sakli et al.,2020). Farmers able to apply pesticides, fertilizers across a field rather than uniformly with help of Artificial intelligence and machine learning technologies, which is based on AI's special analysis of fertility of soil, health of crop and presence of pest at different locations. Farmers can increase quantity of yield except reducing waste and impact of environmental factors by applying resources they mostly needed (Anandkumar et al., 2022; Vinoth et al., 2022; Nanthini et al., 2022) and (Siddhartha et al., 2021; Lakkannavar.,2022).

Predictive maintenance of AI-driven tools used for efficient machinery of farm with number of failures potential of predictions and performance optimization. Algorithms of ML monitor data from sensors in equipment of agriculture for prediction of maintenance to require AI-driven predictive maintenance helps in the efficient operation of farm machinery by predicting potential failures and optimizing performance, reduced maintenance cost. It will helpful for better overall management of farm at optimal efficiency, thus it is essential to manage the control on infections with primary plant protection and damage for nation's growing population with food security factors (Hidayat et al., 2017; Mahardiko et al., 2017; Tigor., 2017). Crop monitoring which gives real time information is essential for farmers, which also includes the monitoring of soil health, mapping of field, weather forecast and variable rate technologies for better performance of crop.

With help of these advanced technologies farmers can take proper guidance for improvement of crop quality and decrease the losses of crop. IOT and artificial intelligence indicates the model his technology can help farmers take the proper steps to decrease crop losses and improve production quality. Technology such as IOT and AI is highly beneficial for detecting quality of soil, conditions of climate changes, requirements of crop with smart crop monitoring. The effect of smart crop monitoring, technology started range from small scale applications of farming such as crop protection, management of pesticides of local farms and weeding to large scale area ones like remote sensing at global level, forests, farmer fields and grassland areas.

In addition, Regulatory and Government authorities for smart crop monitoring are frequently action to provide the growth rate of market. Under this strategy, by using the artificial intelligence, cloud computing, block chain, big data analysis, increment of smart agriculture aims by the government. Assisting farmers with smart crop monitoring for growth productivity of crop and gives higher yield., which is leading to substantial growth. From one of the studies of research BIS research analyses the smart crop monitoring globally was in 2021 ($1.92 billion), expected to increase growth rate CAGR (12.75%) and up to $3.95 billion in 2027 (FAO 2019).

Challenges of AI and ML in Crop Management

Whil imaging technology presents tremendous opportunities, obstacles like scientific complexities, higher cost for updates, also limited access to advanced technologies in developing regions can slow down adoption. However, advancements in cloud-based analytics, machine learning, and cost- effective solutions are expected to drive widespread implementation in the coming years. Agricultural land areas, with help of crop monitoring system make use of profit of water supply by android based mobile applications such as SMS based information as automated on-off power system. For improving crop management system and different type of limitations promised beneficial solution with help of Artificial intelligence and machine learning, which focusing based on algorithms for big or large datasets for unpredicted conditions and training of data. With limited infrastructures of technology regions collection of data can be unpredictable, in agriculture. Biased models lead with the remarkable quality of data. Formatting and scaling of data contrast raise complexities of data from many resources like drone imagery system, weather forecast, health of soil. Agriculture and data science both requires extraordinary knowledge for the execution of AI

and machine learning in crop management (Kassim et al., 2020) and (Goyal et al., 2019; Mundra et al., 2019; Shetty et al., 2019). To maintain the system and emplace also the agronomists and farmers constantly lack of technical expertise for supports effectively. Besides AI models such as deep learning has complexities to make difficulties for interpret and assurance, which also plays important role for the decision-making models in agricultural area (Ghadge et al., 2018; Kulkarni et al., 2018; More et al., 2018; Nene et al., 2018; L et al.,2018). Significant upfront Investment in Hardware such as drones and software involves adoption of artificial intelligence and machine learning technologies in agriculture. These technologies adopted the limited widespread at ground level for small scale farmers, the costs can be forbidden. In developing countries, for famers it is challenging to access these ai- driven tools also the maintenance and updates can also add financial budget problem (Suma et al., 2017; Samson et al., 2017; Saranya et al., 2017; Shanmugapriya et al., 2017; Subhashri et al., 2017). An important barrier to adoption of AI and ML, in several rural areas lack of infrastructures like electricity, internet connectivity, technical support making it challenging. Benefit from AI-driven crop management solutions cannot be effectively implement or beneficial for the farmers without the necessary infrastructure (Nagaraja et al., 2019; Soppimath et al., 2019; Soumya et al., 2019; Abhinith et al., 2019). Digital divide, Job displacement, privacy of data ethical concerns related to the use of AI and ML in agriculture.

Due to anxious about privacy and data ownership farmers may be hesitate to share. Particularly in regions where agriculture is a major source of employment, usually task performed by laborers could lead to job losses. Well-off farmers being able to access the advanced technologies with intensify the inequalities with digital divide (Hidayat et al., 2017; Mahardiko et al., 2017; Tigor., 2017).

Models based on AI and ML usually need to customized for farming practices, regions, specific crops for the better performance. Different agricultural system techniques of these technologies make this requirement scaling challenging. Further, the heterogeneity in agriculture refers to across wide area of agriculture system, resources and practices and outcomes, which is effective in policy making and agricultural development.

Utilizing the authority of AI:

Providing complete picture of crop health for plant growth, system will control the AI to data collection and analyses data from several resources. How to work with it:

Information Gathering:

Detector- Sensors can be known as detector which can be used for gathering real time data depend on factors such as soil health, humidity, temperature, weather forecast.

Satellite or Aerial Imagery- This will help to provide high resolution images of crops as data with help of devices such as drones in plant growth season.

Remotely sensed data using AI analysis- This data known as vegetation indices, which is used to analyze data collection with advanced algorithms of AI. These indices originate from the color range of life cycle of plant and to make valuable perception within:

Green pigment of Plant: photosynthesis and demonstrate all over the health of plant, due to measures of chlorophyl responsible for this.

Thickness of the Leaf: Enables to understanding the stress level of plants and also the capability of water shortage.

Moisture Levels: Analysis of moisture content in plants and surrounding soil.

Climate Fluctuation: it will identify the damaged crops with ability of excessive temperature.

Process: Strategy of analysis of field with learning-based modification

Addition: Data from agricultural land based on real-time, Climate (Temperature), Soil Health, Humidity and Location.

Outcome: Ratio of accuracy and prediction of crop from agricultural area.

1. To bring necessary system for tampering with agriculture land information.
2. Collection of data from the real time data including climate, soil health, humidity and location from farm area.
3. To remove the facts regarding to commas and separate it in array used indexed for plotting.
4. Fill the set of data which is previously trained by use the strategy of learning, also it will actively depend on real time data collected from agricultural area of farming.
5. Promotes margin levels of dataset such as Humidity, temperature and weather each parameter of data.
6. Model validates the parameters of testing with help of limits.
7. If the level of threshold behaves normal, it will store the information in to server attach it to model of dataset for also reference.

Executable Understanding for farmers:

AI system provides farmers through exploration of dataset:

- Assessment of Plant Health: This system makes the health of plant growth evaluate of the highlighted area for concern.
- Premature spotting of obstacle: Possibility of risk like diseases, nutrient, and pests will be identified by the artificial intelligence in advance causes by major losses of crop. With help of early detection farmers can take action by timely required for cure.
- Suggestions for improving protection: AI system helps to improve suggestions for actual problem of plant diseases, early-stage situations which are based on the type of crop:
- Schedule of Irrigation: Enhance schedule for water which is based on requirement of moisture of real time data.
- Compost strategy: Adapting compost utilization to define exact insufficiency for nutrients.
- Tailored Control on Pest: Provide suggestions to use of pesticides, fungicides with only limits or required area.
- Upgrade supervision of Resources: Such as pesticides, fertilizer and water used based on suggestions on capable secure system with data-driven.

On the other hand, significant features are like:

- Information Insurance: Protect the secrecy and sureties of information of assemble data is essential.
- Specialized Understanding: For farmers use of system successfully with help of instruction and protection possibly important.

Not prevented by these factors, ability of artificial intelligence for management of crop protection is highly unarguable. An important scheme based on this plan indicates in the direction of smart and environmentally-friendly agriculture.

Farming Industry Modification Based on Artificial Intelligence-

Farming or agricultural area with digitalize platform over the global industries is smaller noticeable. Yet, enhancement of current industries given expected change to noticed in greater quantity of organization or industry amplify their contributions of product with help of information gathering, benefits of analysis and precision agriculture robots. Methods of smart farming are being execute appreciation to farming techniques, which is more knowledgeable and more productive, also beneficial to increment of growth of productivity and activities in agriculture used by internet of things (IOT) as well as modern technology.

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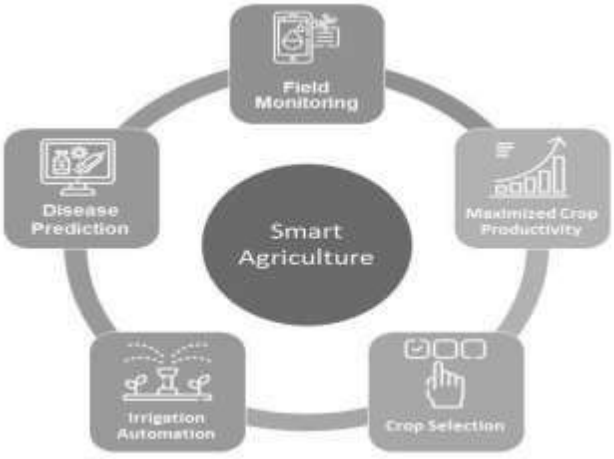
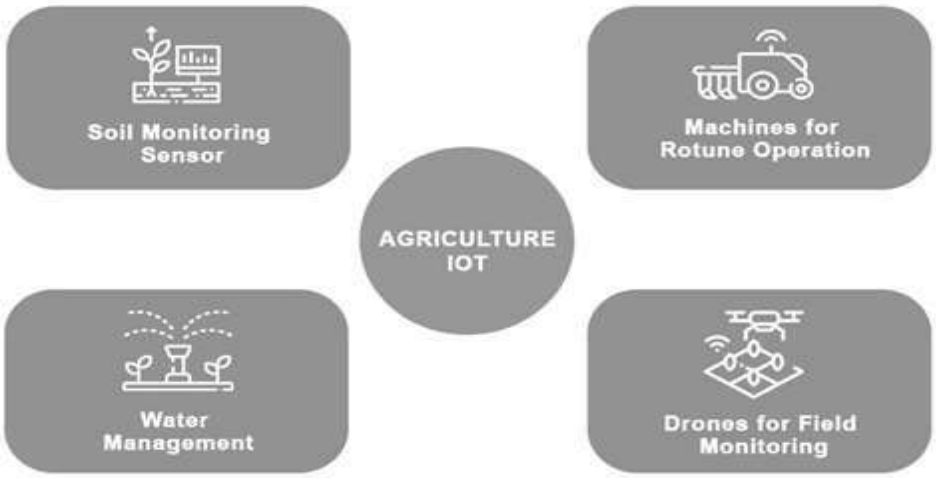
To illustrate, by designing of several elements for creation of smart agriculture farms and more productive with



help of AI expected minimize the superior credential of repeated efforts of physical activities.
Modified Agriculture Industry Based on IOT

Precision Farming is best in agriculture area based on IOT. Enhance accuracy and management of farming proceedings at what time to make something new productive and growth of crops with clearly seen results. Farm management plays important role in area of profession of controlling system, robotics, automated hardware and software, sensor system, numerical tools, self-directed vehicle, technologies related to variable rate.



Precision and Monitoring Control of Farming in Agriculture Based on IOT

Outcomes and Future Prospect

In the industry of agriculture in the state of being in trouble with strain and and concerned caused by the demand in the area of food globally, farmers constrain to grow the area of farming to increase the prosperity prevented by diminishing arrangements of yield in different areas of main food crops known as staple crops. To reduce these difficulties, cultivators and the sector of agriculture internationally depending on transformation of advanced technology of farming with growth rate of production and also the method of

computerized production. Using AI and IOT with AI-driven tools, data-driven analytics, algorithms of machine learning and imaging of real-time data contains monitoring of crops for increment of production output with help of deriving smart farming. Framers appoints best data-driven suggestions for widespread area, measure reachable solutions of imaging based on real-time data which is protecting organic and yielding agricultural activities.

With the support of industry players and stakeholders can better understand market dynamics and capitalize on emerging opportunities. As imaging technology continues to advance, its integration with AI, IoT, and smart farming solutions will further drive efficiency, sustainability, and profitability in global agriculture.

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Conflict of Interest Statement

Authors declare no conflict of interest

Authors Contribution

SP contributed to the project idea, design. PR and SP executed the study. PR and SP supervised the experiment and wrote the manuscript.

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