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IoT Based Smart Farming

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Abstract: The revolution brought by Internet of Things (IoT) technology has affected every field of common man's life, making everything smart and intelligent. In the past, the ripeness of the soil and crop growth were determined by farmers based on their intuition and suspicions. They were unaware of factors such as humidity, water levels, and especially weather conditions, which negatively impacted farmers.

The agricultural sector is being transformed by the Internet of Things (IoT), empowering farmers through a wide range of techniques. In the era of IoT, extensive research is being conducted to develop Smart IoT-based products that facilitate Smart Farming in terms of Crop Management, Pest Management, Agriculture Precision, Agriculture Fields Monitoring through Sensors, and even Drones. The production rate of crops in agriculture depends on various parameters such as temperature, humidity, and rainfall. Therefore, the project aims to make agriculture smart using IoT technologies and the utilization of Unmanned Aerial Vehicles (UAVs), also known as drones, and connected analytics, which have great potential to address and support some of the most pressing issues faced by agriculture in terms of accessing real-time quality data that can be acted upon.

The basic purpose and use of drones for spraying plants could allow for the rapid application of plant protection agents on growing areas. Accordingly, this paper presents the applicable types, role, and significance of drone usage in modern agriculture. This paper provides an overview of various technologies used to reduce human efforts in various agricultural operations, such as detecting the presence of pests, spraying of UREA, spraying of fertilizers, crop mapping, and soil analysis, among others.

Keywords: Unmanned Aerial Vehicles, Smart agriculture, Drones, Internet-of-Things (IoTs), Sensor.

I. INTRODUCTION

A vital role is played by agriculture in the development of agricultural countries. In India, farming supports approximately 70% of the population, and one-third of the nation's capital comes from farming. The fundamental source of food grains and other raw materials, agriculture is considered the foundation of life for the human species. It plays a crucial role in the growth of the country's economy and provides significant employment opportunities.

The future of agriculture is expected to see a growth of 4 billion by 2020. Data generated from sensors in agriculture fields can also be utilized for data analytics, enabling farmers to improve crop yields. Therefore, IoT-based smart farming has the potential to address many agricultural issues.

Applications such as soil moisture monitoring, environmental condition monitoring (temperature, moisture, soil type, crop, crop variety, season), fertility status if available, supply chain management, infrastructure management, humidity maintenance, and theft detection are necessary for agriculture products. Accurate and up-to-date information on the extent and status of monitored resources has always been essential for agricultural entrepreneurs and national early warning systems. Agricultural aircraft have been used for this purpose since the 1920s. Satellite remote sensing data has increasingly been used to assess crop distribution, extent, and health from the sky. In recent years, unmanned aerial vehicles (UAVs) or drones have gained significant attention and are utilized by professionals in various fields. While UAVs are unlikely to completely replace manned aircraft or satellites, they offer several advantages over traditional remote-sensing methods. Drones can collect very high-resolution imagery below cloud level, providing more detailed information than typically available to analysts in developing countries. They are user-friendly, with most drone mapping and data collection missions being conducted autonomously. Additionally, data processing applications are becoming more affordable and user-friendly.

Precision farming combines sensor data and imaging with real-time data analytics to enhance farm productivity by mapping spatial variability in the field. Data collected through drone sorties offers a wealth of raw data for activating analytical models in agriculture. Drones can conduct soil health scans, monitor crop health, assist in irrigation scheduling, apply fertilizers, estimate yield data, and provide valuable information for weather analysis, thus supporting precision farming. The collected drone data, when combined with other data sources and analytic solutions, offers actionable information. Drones are unmanned aircraft operated remotely without a human pilot on board.

They have significant potential in agriculture for supporting evidence-based planning and spatial data collection. Despite inherent limitations, these tools and technologies can provide valuable data that can influence policies and decision-making.

II. LITERATURE SURVEY

The popularity of drones used in agriculture has been stressed by Paolo Tripicchio in the paper "Towards Smart Farming and Sustainable Agriculture with Drones" presented at the International Conference on Intelligent Environments (IE) in 2015. Different plowing techniques can be distinguished by connecting an RGB-D sensor to the drone, and two different algorithms are used to differentiate between the plowing fields.

Marthinus Reinecke, in the paper "The influence of drone monitoring on crop health and harvest size" presented at the 1st International Conference on Next Generation Computing Applications (NextComp) in 2017, has proposed the usage of drones to improve crop quality. The aim is to help farmers increase their production by detecting loopholes beforehand. Specific cameras connected to the drones can be used to detect water shortages and harmful pests, thus managing the crops effectively.

Rodrigo Filev Maia, in the paper "Precision agriculture using remote monitoring systems in Brazil" presented at the IEEE Global Humanitarian Technology Conference (GHTC) in 2017, has discussed an IoT device used for monitoring various agricultural parameters. The device utilizes a network of sensors to measure soil temperature, humidity, moisture, etc. The test was carried out in Sao Paulo, Brazil, and reference climate data was used to support decision-making regarding crop life and sustainability.

D. Yallappa, in the paper "Development and evaluation of drone-mounted sprayer for pesticide applications to crops" presented at the IEEE Global Humanitarian Technology Conference (GHTC) in 2017, has proposed the design of a drone for spraying necessary chemicals on crops. This design helps reduce the cost of pesticide application. The proposed sprayer consists of 6 BLDC motors, and a 5L capacity conical chamber holds the pesticide solution. A DC motor coupled with a pump pressurizes the solution into fine droplets using four nozzles. The entire process is controlled using a transmitter at ground level, and a camera is used to monitor the live spraying operation. The paper entitled "Agriculture Drone for Spraying Fertilizer and Pesticides" by Prof. P. P. Mone, Chavhan Priyanka Shivaji, Jagtap Komal Tanaji, Nimbalkar Aishwarya Satish discusses the implementation of an agriculture drone for automatic spraying mechanism. The authors highlight the problem stated by the World Health Organization, which estimates 3 million cases of pesticide poisoning and up to 220,000 deaths each year, primarily in developing countries. The paper also emphasizes the precautions farmers should take to avoid the harmful effects of pesticides and fertilizers. The technology used in the paper is cost-effective and involves components such as a PIC microcontroller for controlling agriculture robots. The paper was published in IJRTI, Volume 2, Issue 6, 2017.

III. CHALLENGES

In the Republic of India, a multiproduct agricultural nation with highly diverse topography, climate, and soil, the country's small-sized, family farms practice a unique kind of mixed agri-horti-livestock farming, which is an ideal cost-effective model for other developing nations with small farms. The Indian farmers engage in multitasking and easily shift from crop cultivation to animal husbandry, remaining actively involved throughout the year. The versatility of this farming system has transformed the Indian agricultural sector, contributing 17.32 percent to the country's Gross Value Added in 2016-2017 (Statistics Times, 2017). However, Indian agriculture still faces limitations due to factors such as unpredictable weather, scattered and small landholdings, non-scientific farming practices, and poor technological adoption. These factors highlight the urgent need for technological intervention in the agricultural system. To keep up with global agriculture, farming needs to become more technologically driven, relying on real-time information to enable farmers to make more informed decisions.

There are several challenges associated with the implementation of UAVs in the agricultural context:

1) *Quality Software* - The applicability of this technology relies heavily on quality software, from planning the flight path to processing the final image.
2) *Legal Aspects* - Each nation has its own regulatory regime regarding the use of UAVs in agriculture.
3) *Acceptability on the Farmer Front* - Technological unawareness among farmers may hinder its penetration.
4) *Flight Time and Flight Range* - Most drones have short flight ranges, limiting the acreage they can cover. Drones with longer flight ranges are relatively more expensive.
5) *Initial cost of Purchase* - Drones with features suitable for agricultural use can be quite expensive.
6) *Interference with the Airspace* - Drones share the same airspace with manned aircraft, posing potential challenges and risks.
7) *Connectivity* - Many farmlands may lack good connectivity, requiring farmers to invest in connectivity or purchase a drone capable of capturing data locally for later processing.
8) *Weather Dependency* - Drone operations are heavily dependent on climatic conditions, which can limit their usage.

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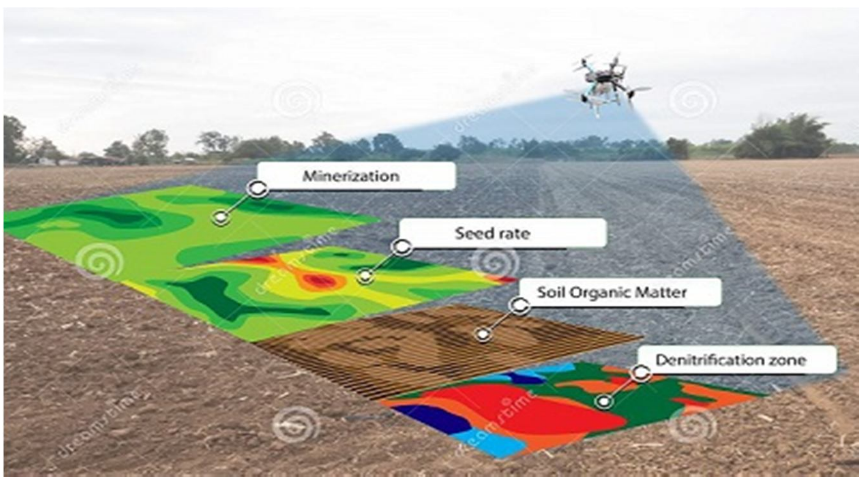
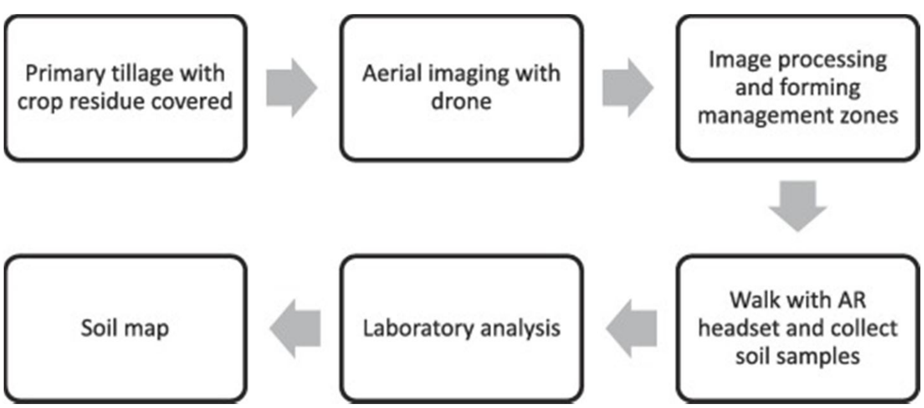
IV. METHODOLOGY TO BE USED

Unmanned aerial vehicles (UAVs) or unmanned aerial systems (UAS), commonly known as drones in a technological context, are unmanned aircraft that can be controlled remotely or fly autonomously. They operate with the assistance of GPS and other sensors mounted on them. According to a recent analysis by PwC, the total value of drone-powered solutions in all applicable industries exceeds USD 127 billion. While drones were previously primarily associated with military and warfare, they have now found applications in various fields due to technological advancements. With the global population projected to reach 9 billion by 2050 and agricultural consumption expected to increase by 70 percent during the same period, agricultural producers need to embrace emerging technologies such as UAVs. Drones used in agriculture serve as low-cost aerial camera platforms equipped with GPS-based autopilot systems and sensors for data collection. They can be compared to regular point-and-shoot cameras for capturing visible images. However, drones equipped with multispectral sensors expand the capabilities of this technology, allowing farmers to gather information beyond the visible spectrum. This includes assessing moisture content in the soil, plant health, stress levels, and fruit evaluation. Such data can help overcome various limitations that hinder agricultural production. PwC estimates the potential market for drone-powered solutions in agriculture to be USD 32.4 billion. The application of UAVs in agriculture enables real-time access to farm information and can be used at different stages of the cropping cycle:

A. Soil and Field Analysis

Precise information obtained by drones can be used to analyze the soil before crop sowing, aiding in determining the most suitable crop for specific land and suggesting the appropriate seed type and planting patterns. Throughout the crop cycle, drones can also be employed to gather valuable data on soil quality. By creating 3D maps of the soil, potential issues related to soil quality, nutrient management, or dead zones can be identified. This information assists farmers in making informed decisions regarding planting patterns, crop management, soil improvement, and effective water resource utilization. Ongoing monitoring enables better management of crop nutrient levels.



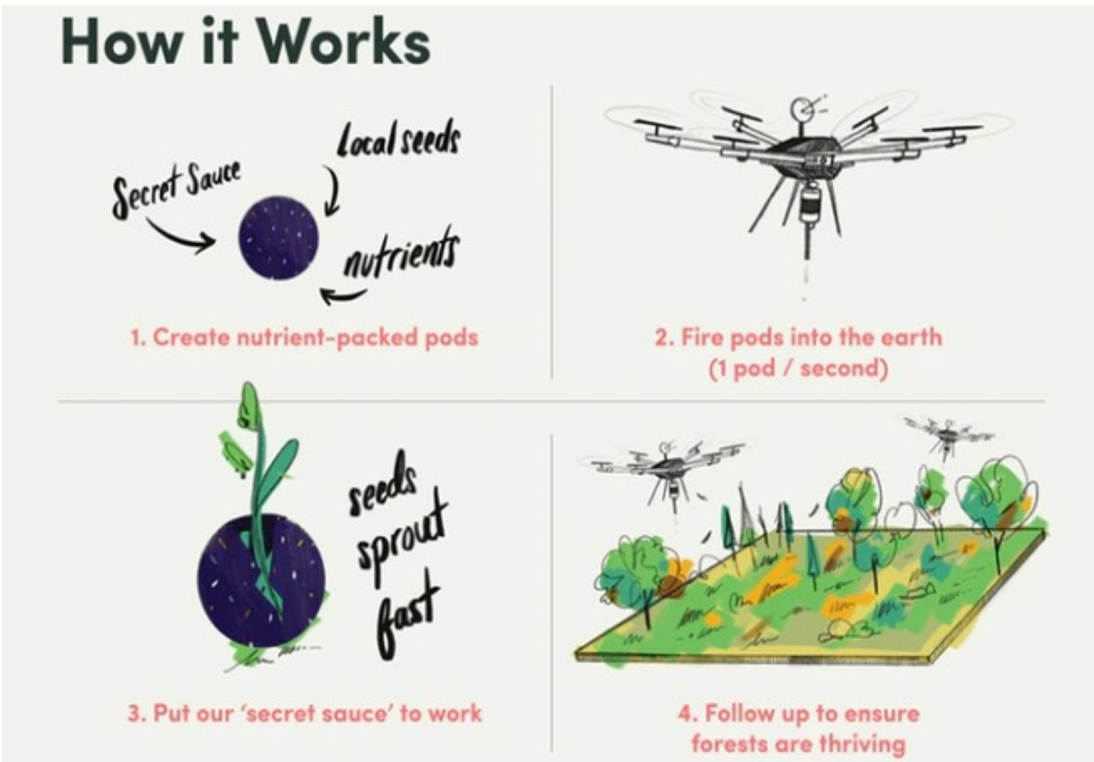


Seed planting systems based on drones are being developed to decrease planting costs up to 85 percent, addressing the issue of millions of acres of under-utilized land due to inaccessibility or lack of suitable workers. The main reason for not utilizing these areas for forestry or agriculture purposes is safety concerns related to rough terrain. Notably, some recently developed drones have the capability to plant 100,000 trees in a single day, significantly reducing the time required for planting operations.

In these drone-based systems, pods containing seeds and necessary nutrients are shot into prepared soil. This method has proven highly effective for rough terrain, with a success rate of more than 75 percent. Due to the success and flexibility they offer, UAVs are being widely considered as the best option for plantation projects worldwide.

Drone planting, although a relatively newer technology and not yet widely used, is being experimented with by some companies. Manufacturers are conducting experiments with custom systems capable of shooting seed pods into the soil. Drone startup companies have played a significant role in developing unique drone technologies to address a wide range of ecological and agricultural issues.

For instance, DroneSeed, a company specializing in drones, is utilizing unmanned aircraft capable of delivering up to 57 pounds of payload, including tree seeds, herbicides, fertilizer, and water per flight. This technology is being applied to assist reforestation and replanting projects. By minimizing the need for on-the-ground planting, which can be costly, time-intensive, and physically demanding work, this drone technology helps reduce overall planting times and labor costs. Moreover, it can be adapted and applied to various farm types, further enhancing efficiency in agriculture.



The correct amount of liquid can be sprayed by drones by scanning the ground, modulating the distance from the ground, and spraying in real time to ensure even coverage. This leads to increased efficiency and a reduction in the amount of chemicals penetrating into groundwater. In fact, experts estimate that aerial spraying can be completed up to five times faster with drones compared to traditional machinery.

In order to maintain high yields, crops require consistent fertilization and spraying. Traditionally, these tasks were performed manually, with vehicles, or even using airplanes. However, these methods are not only inefficient and burdensome but also costly. With approval from the FAA, drones can be equipped with large reservoirs filled with fertilizers, herbicides, or pesticides. Using drones for crop spraying offers enhanced safety and cost-effectiveness. Drones can be operated autonomously and programmed to follow specific schedules and routes. For instance, if there is a fungus breakout in a particular section of the crops, drones can be utilized for spot treatment. The speed at which drones can operate allows for the timely diagnosis and treatment of potential crop issues before they spread throughout the entire farm.

B. Crop Mapping and Surveying

Drone technology offers significant advantages for large-scale crop and acreage monitoring. Unlike expensive and imprecise satellite or plane imagery, drones provide real-time footage and time-based animation for accurate crop monitoring. Drone mapping and surveying enable data-driven technology decisions based on real-time information. Near-infrared (NIR) drone sensors can determine plant health by analyzing light absorption, offering a comprehensive view of overall farm health. Drones have been successfully used in vineyards to assess grapevine health. With agriculture drones, farmers can collect information such as crop and plant health, land distribution by crop type, current crop life cycle, and detailed GPS maps of crop areas. Ultimately, drones help optimize land and resource utilization while aiding farmers in making informed decisions about crop planting locations.

C. Irrigation Monitoring and Management

The use of drones for irrigation applications has a dual purpose. On one side, sensors and cameras can be equipped on UAVs to identify areas experiencing water stress and determine necessary irrigation adjustments. Additionally, drones can be employed to precisely sprinkle water and pesticides on crops, particularly in emergency situations, resulting in time and resource savings. Multispectral images of citrus crops were acquired using a fixed-wing UAV, and the collected data was utilized to assess and detect structural and physiological changes in the targeted crop. Moreover, UAVs are not only utilized for analyzing irrigation properties but also provide solutions by precisely sprinkling water over areas experiencing water stress. These applications position UAVs as the newest tool for water conservation, as they contribute to increased watering efficiency and the detection of potential pooling or irrigation leaks.

Some drones are equipped with thermal imaging cameras that enable livestock to be managed and monitored by a single pilot. This allows livestock to be tracked at a higher frequency and with fewer time and personnel resources required. The herd can be quickly checked by the drone operator to identify any injured or missing livestock, as well as to observe animals giving birth. Drones are utilized to constantly monitor the herd, which was once a costly and time-consuming task.

Furthermore, thermal imaging helps to identify potential livestock predators, providing a significant advantage for farm owners.

V. CONCLUSION

In the future, agricultural drones will become an integral part of smart farming, assisting farmers in addressing various challenges and reaping numerous benefits. Drone technologies present a unique opportunity for the EU economy to generate additional growth and prosperity. With the increase in population, drones or UAVs will be of immense help in agriculture, particularly at the beginning of the crop cycle. They will not only reduce time but also facilitate improved cultivation based on analyzed data. Drones are not only used for soil and field analysis but also for planting seeds and delivering plant nutrients to the soil. Systematic monitoring through drones will enhance crop management efficiency. With advancing technologies, the production rate will increase rapidly while consuming lesser energy. By accessing a vast pool of data, farmers can increase crop yields, save time, reduce expenses, and operate with unparalleled accuracy and precision. One significant advantage of drones is their auto-landing capability, which reduces risk factors and is designed in a simple and cost-effective manner. This study highlights the importance of drones in agriculture and serves as an eye-opener for industry and agriculture to further develop and integrate drones for enhancing agricultural tasks in the near future.

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