Smart breeding for smart farming

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Introduction

Smart agriculture is an evolving field that leverages technological innovations to transform traditional farming practices. The integration of digital technologies into agriculture has opened up new opportunities and possibilities, revolutionizing the way farmers Manage their crops, resources, and operations. It is a rapidly evolving field that encompasses a wide array of approaches, applications, and impacts. The broader objective of this review is to delve into the essential aspects of precision agriculture, exploring its key Components and highlighting its potential for sustainable farming practices. One of the Critical aspects of precision agriculture is data collection and acquisition planning, which Plays a fundamental role in


optimizing farm management decisions. Through efficient data Gathering, farmers can make informed choices regarding crop health, resource allocation, And yield optimization. Decision making and execution are also vital components of precision agriculture, where the integration of cutting-edge technologies is pivotal. Leveraging Machine vision technology, the Internet of Things (IoT), and artificial intelligence (AI) can Lead to enhanced precision and efficiency in agricultural processes, benefiting both farmers And the environment. Throughout this review, successful precision agriculture proposals And real-world implementations are analyzed to gain insights into their achievements and Challenges. By identifying future developments required in precision agriculture, we aim To provide a comprehensive understanding of how this field can continually evolve to Support sustainable farming practices and address global food security challenges. The Amalgamation of scientific research and technological innovations holds great promise for The future of precision agriculture and its positive impact on agriculture and society as A whole.

Precision Agriculture: The Next Frontier for Sustainable Farming

Intensive approaches, which deploy machines at each and every step in agriculture , namely diagnosis, decision making, and performing. Human power is Only involved in monitoring and maintaining]. Apart from the gradual modification Of agricultural practices by the three previous industrial revolutions, the ongoing fourth Industrial revolution is shaping the current status of agriculture, leading to Agriculture. This new discipline is characterized by data-driven management; new tool-based production, sustainability, professionalization; and the reduced environmental footprint of Farming with intensive approaches , which deploy machines at each and every step in agriculture namely diagnosis, decision making, and performing. Human power is only involved in monitoring and maintaining . Apart from the gradual modification of agricultural practices

by the three previous industrial revolutions, the ongoing fourth industrial revolution is shaping the current status of agriculture, leading to Agriculture . This new discipline is characterized by data-driven management; new tool-based production, sustainability, professionalization; and the reduced environmental footprint of farming with modern smart technologies , such as robot technology (including drones), big data, artificial intelligence, computer vision, 5G, cloud computing, the Internet of Things, and block chain technology. This makes agricultural production systems more autonomous and intelligent. Therefore, the following involvements can be identified as new trends and precision agriculture , where new capabilities are introduced to smart farming modern smart technologies , such as robot technology (including Drones), big data, artificial intelligence, computer vision, 5G, cloud computing, the Internet of Things, and block chain technology. This makes agricultural production Systems more autonomous and intelligent . Therefore, the following involvements Can be identified as new trends and precision agriculture , where new capabilities are introduced to smart farming
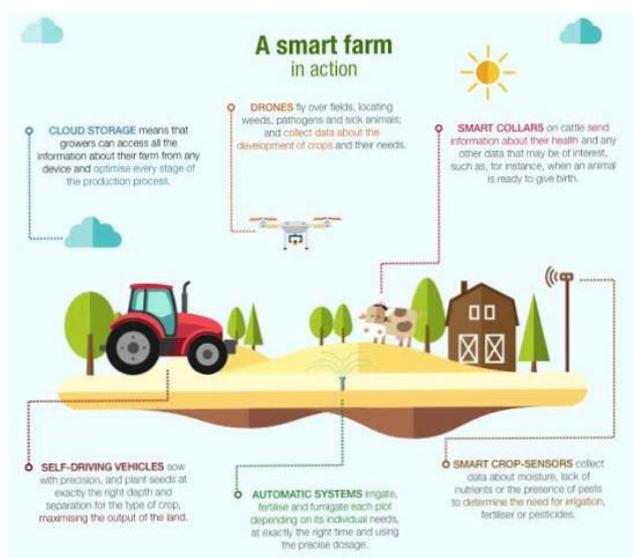
Machine Vision Technology

Precise and accurate data and information are the driving components of precision Agriculture. Recently, image analysis has become a more reliable data source than manual, labor-intensive, costly data-collecting methods . Here, machines can read and Understand the real world through pixel images and produce accurate site-specific information . Machines with 'eyes' in agricultural activities are called machine vision (MV). This, Also known as agro-vision or the 'eyes' of robots, provides non-destructive, robust, rapid, And steady methods to monitor cultivation processes. MV systems give machines their Vision and judgement capabilities in image processing and data extraction . Although MV technologies have already been applied successfully for crop species identification, Crop stress detection, crop seed quality assessment, weed detection, disease detection, etc., they are still at the prototype stage. Currently, emerging deep-learning (DL) techniques in Growing machine-learning (ML) technologies are integrated with MV applications in order To develop intelligent robots for multispectral imagery analysis and real-time analysis in Field variable rate applications . Commercial smartphones, which are ubiquitous Among the human population, are able to be used in monitoring crop health and stress Based on MV systems

Internet of Things (IoT)

The IoT refers to a network of interconnected items and technologies . The IoT is one of the most important technological advancements in precision agriculture and Smart farming [5]. IoT architecture for agriculture, such as agricultural sensors with ICT and UAV, collects data for precision agriculture . Also, the burgeoning IoT an mobile data are the core of the fourth industrial revolution . Meanwhile, advancements communication technologies and wireless networks (5G, LoRaWAN, NB-IoT, Sigfox, zigBee, and Wi-Fi) have broadened the application of the IoT in diverse fields, such as Real-time remote control and high-throughput phenotyping, while giving better coverage, bandwidth, connection density, and end-to-end latency. When it consolidates

In agriculture together with cloud computing, it results in smart farming for various scopes of livestock monitoring, smart greenhouses, fishery management, and weather Tracking The IoT can be widely used in all areas of precision agriculture with the Development of sensors with independent intellectual property rights and the development Of smart devices, such as intelligent tractors, UAVs, and robots that can high levels

Conclusion

Smart farming represents a transformative shift in global agriculture, integrating digital tools, automation, and data-driven decision-making to enhance productivity and sustainability. The rapid advancement of technologies such as machine vision, IoT, AI, cloud computing, robotics, and wireless communication networks has enabled farmers to monitor, analyze, and manage crop production with high precision. Although many technologies remain in prototype stages, their potential for large-scale adoption is immense. Precision agriculture will remain central to addressing future challenges, including climate change, resource scarcity, and global food security.

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