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Integrating AI with Traditional Agriculture Practices

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Abstract

Agriculture, which is a cornerstone pillar of economic development and sustainability, is being revolutionized to respond to increasingly emerging challenges like climate change, crop diseases, resource degradation, and population pressure. Farming practices that were long based on traditional practices embedded in indigenous knowledge are now increasingly being complemented with technological innovations to stabilize food security and environmental resilience. One such innovation is Artificial Intelligence (AI), which is an essential facilitator of modernizing agriculture. This essay discusses the convergence of AI with conventional agricultural methods, with emphasis on the use of hyperspectral imaging technologies on different platforms—airplanes, satellites, close-range systems, and drones. These technologies, in conjunction with AI-enabled data analytics, provide greater precision and effectiveness in tracking the health of crops, soil, and environmental stressors. The paper analyses how every hyperspectral platform gives something special to agricultural productivity and how AI enables the interpretation of data and decision-making. Through connecting conventional knowledge to sophisticated AI applications, this study gives a glimpse into the future direction of sustainable, intelligent, and adaptive farming systems that can respond to existing and emerging needs of agriculture.

Keywords: agriculture, artificial intelligence, sustainability, innovation

Introduction

Agriculture is at the center of economic sustainability for most countries. It is crucial to long-term economic development and structural change in various economies. Traditionally, agricultural activities were mostly confined to food and crop farming. (Mellor JW 2018). Today, though, the industry is confronted with a broad variety of complicated issues such as crop diseases, climate change, depleting environmental resources, and a rapidly increasing global population. As a response, contemporary agriculture is going through a shift towards enhancing conventional farming techniques using cutting-edge technologies. (Raj, M et al., 2025)

Artificial Intelligence (AI) is poised to become a powerful tool for tackling complex challenges in agriculture. Facilitated by robotics, big data analytics, the Internet of Things (IoT), sensors, camera systems, and drone technologies, AI is transforming the manner in which farm data is gathered, analyzed, and utilized. Hyperspectral imaging, one of the most influential innovations in this space, presents precise information about crop health, soil health, and environmental stressors.

Hyperspectral sensors have become more widely available and affordable over the past few years, and are increasingly being put onto a range of platforms—airplanes, satellites, near-range

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instruments, and unmanned aerial vehicles (UAVs). Each platform provides distinct benefits:

Aircraft have been the prevalent platform for agricultural hyperspectral imaging for many years. Airplanes are used extensively for monitoring, and scientists tend to use AVIRIS (Airborne Visible/ Infrared Imaging Spectrometer) data to study a wide variety of agricultural traits.

Satellites, while used less often for hyperspectral imagery than multispectral sensors, have been instrumental through sensors like Hyperion. Hyperspectral data from satellites have aided numerous agricultural research studies on crops, soils, and disease detection.

Close-range hyperspectral imaging, ordinarily lab- or ground-based, has ultra-high spatial resolution, hence perfectly suited to investigate soil characteristics and detailed crop features. It helps procure important information on plant biophysical and biochemical processes, such as their reaction to environmental stress factors and diseases.

UAVs (Unmanned Aerial Vehicles) are now one of the most common and affordable platforms used for hyperspectral imaging in agriculture. Their adaptability, economy, and high-resolution imaging capabilities render them most useful for high-precision real-time monitoring of agricultural fields. UAVs are increasingly being applied in precision farming, crop health analysis, and environmental monitoring, but pose issues like radiometric noise and signal-to-noise ratio calibration.

Integration of AI with such hyperspectral technologies unleashes new horizons in precision agriculture. This article examines the ways in which AI can be best integrated with conventional farming practices, using the data gathered from these different hyperspectral platforms to maximize productivity, minimize risks, and create climate-resilient agricultural systems. (Lu, B et al.,2020)

Review of Literature

These technologies are spread extensive range of agricultural utilization, such as crop yield prediction, crop disease detection, management of the crops, and the monitoring of agricultural water, soil health, and land use. A hyperspectral information system is capable of giving numerous hundred spectral bands that cover the electromagnetic spectrum, which is able to observe a single acquisition (Kenneth LI & Jasmine 2021)

The world's population is rapidly increasing with increased demand for food and labor, and farmers lack proper techniques to meet these demands. Over the past years, agriculture has benefited from artificial intelligence (AI). The key problems of this are numerous applications of AI agriculture, such as weeding, irrigation, spraying with different sensors or other methods, drones, and robots (Shivangi, Kirti, and palak 2022)

Attaining world food security and escalating challenges, such as climate change, disease invasion, population expansion, and resource scarcity. Expected growth in food demand further complicates the crucial issue. In staple crops, losses (up to 41%) in dominant crops such as rice, wheat, soybean, maize, and potato exacerbate the problem. In order to do so, remote sensing systems and hyperspectral imaging (HSI) have emerged as strong and non-destructive sensor methods, yielding promising results in primary disease detection. This review will be written about some technologies, some platforms for remote sensing system for data used collection, successful implementation of the method, and its feasibility view (Faizan ali, ali razzaq 2024).

Need for AI Technology in Agriculture

Agriculture is a labor-intensive profession, and with a growing population and increasing agricultural production requirements, automation is gaining increasing importance. AI significantly assists farmers in components, technologies, and applications. Enhanced predictive analytics and enhanced farm and crop management systems provide crop quality and availability. With satellite images and weather information, businesses measure land area and monitor crop health in real time. Companies can leverage big data, AI, and ML technologies to forecast prices, calculate tomato output and yield, and identify pest and disease infestations. They can guide farmers depending on demand levels, what crop varieties to cultivate for optimal profit, pesticide application, and prices in the future. AI will be a very effective instrument which can help organisations deal with the enhanced complexity of agriculture today as it reduces tremendously limited resources and manpower. It is high time that big companies should invest in the industry. The majority of industries utilize AI technology to optimize product activity and effectiveness. (Mohd Javaid et al.,2023)

Process of AI in Agriculture

It is popularly understood that the data quality used by AI affects the way in which it will effectively handle agricultural matters. AI has been examined as a likely technology to bring about agrarian revolutionary solutions. This is a significant challenge, especially in obtaining the required information at the farm level. The application of farm machinery and efficiency, especially in weed control, early disease detection, and crop harvesting and grading, can be revamped with image classification techniques based on remote and proximal sensing data. (Mohd Javaid et al.,2023)

Hyperspectral Imaging towards Sustainable Farming

Hyperspectral imaging involves gathering data across a very wide range of adjacent spectral possess detailed information regarding surfaces and objects. Agriculture conventional imaging methods gather only a few broad spectral bands, i.e., Red, Green, and Blue. Hyperspectral imaging plays a critical role in sustainable agriculture in measuring numerous accepts of environmental conditions, crop health, and nutrient status. (Vairavan et al., 2024)

Big Data Causes with Spectral Information

In recent years, hyperspectral sensor systems have the capabilities of creating a very high-dimensional imaging great quantity of spectral bands through the use of a sensor system. These technologies are within reach to distinguish materials based on spectral information and have provided detailed information about the sensor system. A hyperspectral image single scene can be demonstrated as a large volume (3D) with two spatial dimensions, with data cube, and one spectral dimension, and three dimensions in this technology. (Li-minn ang et al.,2021)

Limitation

Lack of easily accessible solutions that embed and integrate Farm AI is one of the biggest barriers to the mass adoption of AI in farm production. Most farmers don't have the time and computer skills to investigate AI solutions on their own. In order to seamlessly incorporate and implement AI in agriculture, these new AI technologies will have to be embedded in existing and current infrastructure and systems that farmers already have. Agriculture cannot rely on AI alone because it cannot operate outside of its programming. Farmers, particularly in rural communities, lack technical skills and are unaware that there are such technologies. The more awareness created and technologies are made available to the ordinary farmer, farming would be semi-autonomous, with the front end driven by AI. (Mohd Javaid et al.,2023)

Future Scope

In the coming times, AI technologies are offering innovative and precise solutions to the biggest agricultural issues confronting farmers worldwide. AI will provide solutions for almost all things, from pest control to weather prediction to farm work assistance. More exciting discoveries in AI for farming will be developed in the next few years. In the future, farmers can become agricultural scientists with data to achieve maximum yields in certain rows of crops. AI companies are creating robots that are only able to perform various tasks in farms. (Mohd Javaid et al., 2023)

Conclusion

Artificial intelligence-based technologies use information like temperature, rainfall, wind speed, and solar radiation using ML algorithms, and satellite and drone images are used to forecast weather patterns, examine crop sustainability, and evaluate farms for the presence of diseases or diseases and poor nutrition in plants. Wi-Fi-enabled farmers' connectivity can utilize AI software to receive an AI-personalized farm plan. Using AI-driven tools that increase output and income without depleting valuable natural resources, farmers can fulfill the world's demand for increased agricultural output and profitability. Farmers can use AI to gain real-time data on their plots, fields that need watering, fertilisation, or pesticide application. Some new farming practices, such as vertical farming, can help produce food yield with fewer resources. (Mohd Javaid et al.,2023)

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