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Automating the Green: A Comprehensive Overview of Robotics and IoT in Polyhouse Cultivation

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Abstract: *This review paper explores the transformative impact of Robotics and Internet of Things (IoT) technologies on polyhouse farming practices, shedding light on the revolutionary changes that have taken root in agricultural landscapes. Under the lens of our scrutiny, we dissect the intricate fusion of robotics and IoT, unraveling its multifaceted applications within the domain of polyhouse agriculture. From precision farming techniques to real-time monitoring and control systems, this comprehensive review navigates the landscape of technological interventions that are reshaping traditional approaches to cultivation. We delve into the enhanced crop management strategies, resource optimization, and sustainability aspects that arise from the integration of these cutting-edge technologies. As we traverse the uncharted territories of agricultural innovation, this review not only highlights the groundbreaking developments but also underscores their collective potential to cultivate a future where polyhouse farming stands as a beacon of sustainable, efficient, and technologically-driven agricultural practices. Join us in this exploration of how the amalgamation of robotics and IoT is breaking ground and cultivating a promising future for polyhouse farming.*

Keywords: Polyhouse; Smart Farming; robotics; Automation; IOT; Arduino.

I. INTRODUCTION

In recent years, the agricultural landscape has undergone a profound transformation, with technological innovations playing a pivotal role in shaping the future of farming practices. One such paradigm shift is witnessed in the realm of polyhouse farming, where the integration of Robotics and Internet of Things (IoT) technologies has ushered in a new era of efficiency, precision, and sustainability. As we embark on this exploration, our review aims to delve into the groundbreaking advancements that have emerged at the intersection of robotics and IoT, specifically within the context of polyhouse agriculture. This comprehensive examination seeks to unravel the intricate tapestry of technological interventions, their applications, and the impact they bear on reshaping traditional farming methodologies. From enhancing crop yield to optimizing resource utilization, our scrutiny will unravel the multifaceted ways in which these innovations are not only breaking ground but also cultivating a promising future for polyhouse farming practices. Join us on this journey as we navigate through the evolving landscape of agricultural technology, where the fusion of robotics and IoT is revolutionizing polyhouse farming and laying the foundation for a sustainable and technologically-driven agricultural future.

II. PROBLEM STATEMENT

Conventional agricultural practices are facing challenges in meeting the needs of a growing global population while ensuring sustainability and resource efficiency. To address these issues, this project aims to explore "Novel Agriculture Robots" integrated with cutting-edge technologies for polyhouse farming. The focus is on designing, developing, and deploying advanced robots capable of autonomously performing tasks like planting, weeding, monitoring crops, and harvesting. The goal is to identify technical, economic, and environmental obstacles to widespread adoption while optimizing performance, energy efficiency, and user-friendliness. Through this research, the project seeks to revolutionize farming practices, enhance productivity, promote sustainable resource management, and contribute to global food security.

III. LITERATURE REVIEW

A Study on IoT based Low-Cost Smart Kit for Coconut Farm Management: A Review

This paper is a conceptual study that attempts to develop a new, low-cost smart toolkit to solve the problems faced by coconut farm owners with less than 5 acres of land.

Installing a smart coconut set connected to smartphones will help farmers effectively manage agricultural land without needing any labour resources.

To identify the problems faced by farmers, a survey was conducted in Pollachi rural areas.

It was found that farmers in this locality are facing problems in their farms due to the following main causes- Frequent intrusion of elephants in the fields, lack of water supply for farming coconut cultivation, common pests that attack coconut trees.

The annual report of the Ministry of Food and Agriculture (2010) states that small farmers cannot even afford to buy fertilizers and agrochemicals due to poverty and limited access to credit, leading to low crop productivity.

The study aims to create an affordable smart kit model for small coconut farmers with less than 5 acres of land. The smart kit, connected to a smartphone, enables farmers to efficiently manage their farms without manual labour. The kit includes IoT devices such as a Fence alarm, Flow control valve, Soil moisture monitoring device, and Pest alarm, addressing common challenges faced by farmers. These devices send signals to the farmer, allowing them to respond to specific farm conditions. For instance, the moisture sensor detects low soil moisture and alerts the farmer to irrigate. Additionally, the kit helps manage pest issues by detecting their presence and movement. The farmer can control the water flow through a pump based on soil moisture levels. Communication between the devices and the farmer occurs through a wireless GSM module, and the farmer operates the system using a mobile phone with a web-based app. Data is stored on virtual servers maintained by a cloud computing service provider, enabling easy access and management of farm-related information.

Application of IoT in Agriculture: A Review

This paper introduces a solution to automate crop-dusting using drones, aiming to enhance efficiency and safety for farmers. The proposed Internet of Things (IoT) based architecture for smart agriculture includes layers with various components such as a battery-powered system with Arduino, sensors (Temperature, Moisture, Water level), GPRS module, and DC motor. The system monitors and sends SMS alerts regarding moisture and water levels. Sensors trigger the water pump system and fan based on environmental conditions, displayed on an alphanumeric module. The IoT platform provides real-time data on moisture, temperature, and water levels, aiding crop-specific cultivation. The system allows remote control, including shutting off water via IoT. Sensors, drones, relays, and weather sensors connect to gateways, transmitting data to the cloud for remote monitoring and control using smart devices. The IoT architecture enables data analysis, anomaly detection, and crop monitoring, empowering farmers to make informed decisions through an analytical dashboard.

IOT Based Smart Polyhouse System using Data Analysis: A Review

The study proposes an automated IoT-based smart polyhouse system employing Hadoop technologies to enhance polyhouse functionality. The focus is on implementing smart irrigation methods, including drip irrigation, to prevent crop damage from waterlogging. The system comprises sensors, IoT devices, and Hadoop technologies such as Apache Hadoop, Flume, and Hive. The automated polyhouse architecture involves sensing and data gathering, data storage, data analysis, and monitoring and control modules.

The system functions include observing farm parameters, storing observed status, measuring actual performance, automated monitoring through sensors, analysis by comparing observed and measured status with norms, and decision-making and intervention to improve farm processes. The polyhouse farming cycle involves sensing parameters like light, soil moisture, temperature, and humidity using sensors. The gathered data is fed into Hadoop Distributed File System (HDFS) via Flume, and analysis is conducted using Hive technology. Decision-making based on predictive insights controls polyhouse parameters. The study compares the proposed automated polyhouse with other systems, highlighting technology, sensors, output transmission methods, microcontrollers, and circuit complexity.

The designed prototype incorporates Hadoop technologies at various stages of the data supply chain, from data gathering to analysis. The Hadoop implementation involves logging sensor data, creating an HDFS directory, ingesting data into HDFS using Flume, running queries on the data with Hive, and dumping results back into HDFS. After decision-making based on analysed data, parameters under supervision are controlled. The study provides an in-depth view of the proposed automated polyhouse system and its integration with Hadoop technologies.

Smart Polyhouse using Internet of Things: A Review

This paper discusses the application of IoT in addressing challenges associated with maintaining optimal conditions in polyhouses for cultivating vegetables, fruits, and flowers. Polyhouses, a broader term encompassing greenhouses, provide controlled environments for plant growth. However, the lack of awareness or human errors can impact productivity. To mitigate these issues, the authors propose an automated IoT system.

The IoT solution involves connecting sensors and actuators over the internet to monitor and maintain specific conditions in the polyhouse. Parameters such as temperature, soil moisture content, humidity, and light are monitored using various sensors, and the system takes appropriate actions based on the readings. The automated system sends messages to relevant personnel regarding house operations.

The materials and methods section outlines the components used in the solution:

Arduino Uno: A microcontroller board for sensing various data using Arduino IDE.

GSM Modem: Used for transmitting mobile voice and data services in the 900MHz band.

DHT11 Sensor: A digital temperature and humidity sensor with an operating voltage of 3.3v to 5v and a range of 0 to 50 degrees Celsius for temperature and 20% to 90% for humidity.

Overall, this paper presents an IoT-based solution to enhance the monitoring and maintenance of conditions in polyhouses, aiming to improve the quality and productivity of crops.

IoT based Automated Polyhouse Monitoring and Control System: A Review

This paper proposes an Internet of Things (IoT)-based system for crop monitoring and control within a polyhouse. In the IoT infrastructure, interconnected physical devices such as microcontrollers, microprocessors, actuators, and sensors communicate over the internet through an IoT gateway. The proposed system automates the monitoring and control of parameters like temperature, soil moisture, humidity, and light intensity inside the polyhouse. Data from the sensors is transmitted to the cloud and displayed on a server database through a Windows application. The system utilizes low-power wireless components and is designed for easy installation.

IV. RESEARCH GAP

There is a need for a comprehensive investigation into the effectiveness and practical implementation of IoT-based solutions for crop monitoring and control in polyhouses. While the proposed systems outline the integration of IoT, sensors, and cloud technology, there is a gap in understanding of the real-world applicability, scalability, and performance of such solutions. Additionally, research could focus on addressing challenges related to the reliability, accuracy, and security of the data collected from low-power wireless components in dynamic agricultural environments. Furthermore, there is an opportunity to explore the economic feasibility and adoption barriers of these IoT-based systems, considering the diverse contexts and resources available to farmers. Investigating these aspects would contribute to a more robust understanding of the potential impact and limitations of implementing IoT in smart agriculture, specifically within polyhouse settings.

V. CONCLUSION AND FUTURE WORK

In conclusion, the fusion of robotics and the Internet of Things (IoT) in smart farming presents a promising trajectory for the agricultural sector. The review of these technologies in the context of polyhouse farming reveals a landscape marked by precision, efficiency, and sustainability. The deployment of autonomous systems, real-time monitoring, and data analytics has significantly improved crop management practices, resource utilization, and decision-making processes.

As we navigate through this technological landscape, it becomes evident that smart farming is not without its challenges. Issues such as technology adoption barriers, data security concerns, and the need for standardized interoperability have surfaced. To fully capitalize on the potential benefits of smart farming, concerted efforts are required from stakeholders to address these challenges and create an environment conducive to widespread adoption.

Looking ahead, the continued development and integration of robotics and IoT technologies in agriculture hold the key to a more resilient, productive, and sustainable future. The strides made in precision agriculture, coupled with advancements in data analytics and automation, underscore the transformative impact that technology can have on traditional farming practices.

In the face of a growing global population and the imperative to enhance food production while minimizing environmental impact, smart farming emerges as a beacon of innovation. By leveraging the capabilities of robotics and IoT, farmers can navigate the complexities of modern agriculture with greater precision and efficiency. The journey towards a technologically empowered and sustainable agricultural future requires collaborative efforts, research advancements, and a commitment to overcoming the challenges that lie on the path to widespread adoption. As we conclude this exploration, it is evident that the synergy of robotics and IoT is not merely breaking ground in polyhouse farming but is sowing the seeds of a transformative era for agriculture as a whole.

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