Proceedings of the 5th International Conference on Smart Electronics and Communication (ICOSEC-2024)
DVD Part Number: CFP24V90-DVD; ISBN: 979-8-3315-0439-7

Autonomous Precision Crop Planting Robot

Nataraj B
Department of Electronics and Communication Engineering, Sri Ramakrishna Engineering College, Coimbatore, Tamil Nadu, India
nataraj.b@srec.ac.in

Prabha K R
Department of Electronics and Communication Engineering, Sri Ramakrishna Engineering College,
Coimbatore, Tamil Nadu, India
prabha.kr@srec.ac.in

Nitheesh K S
Department of Electronics and Communication Engineering, Sri Ramakrishna Engineering College,
Coimbatore, Tamil Nadu, India
nitheesh.2002159@srec.ac.in

T Venkata Deepthi
Department of Mechanical Engineering, Malla Reddy Engineering College,
Maisammaguda, Hyderabad, India
venkatadeepthi.t@gmail.com

Ramkumar K
Department of Electronics and Communication Engineering, Sri Ramakrishna Engineering College,
Coimbatore, Tamil Nadu, India
ramkumar.2002163@srec.ac.in

***Abstract*—The Autonomous Precession Crop Planting Robot revolutionizes agriculture by seamlessly automating the planting process. Equipped with advanced sensors and AI algorithms, the robot navigates fields with precision, detecting optimal planting locations based on soil conditions and crop requirements. It optimizes seed placement, depth, and spacing, enhancing overall crop yield and reducing resource use. The robot operates autonomously, minimizing human labor and errors. Through real-time data analysis, it adapts to changing environmental factors, ensuring efficient and sustainable crop cultivation. This innovation signifies a significant leap towards smart, data-driven farming, promising increased productivity and ecological conservation.**

Keywords*— Robotic Arm, Servo Motor, Motor Driver, Internet of Things, Cloud, Message Queuing Telemetry Transport.

I. INTRODUCTION

The main objective is to deliver a complete overview about the product. This chapter gives information about the problems that is faced in agriculture field. It also gives a detailed knowledge about the factors that are causing at the time of unavailability of workers. The Autonomous Precession Crop Planting Robot represents a groundbreaking advancement in agricultural technology, poised to revolutionize traditional farming practices. By leveraging a combination of cutting-edge sensors and AI algorithms, this robot offers unparalleled precision in the planting process. Its ability to navigate fields with precision and identify optimal planting locations based on soil conditions and crop requirements ensures efficient resource utilization and maximized crop yield. Moreover, the robot's capacity to optimize seed placement, depth, and spacing further enhances productivity while minimizing waste. One of the most significant advantages of this innovation lies in its autonomy, which greatly reduces the need for human labor and mitigates the risk of errors inherent in manual planting methods. Farmers can now rely on this autonomous system to handle the planting process with minimal supervision, allowing them to focus on other aspects of farm management. Furthermore, the real-time data analysis capabilities of the robot enable it to adapt swiftly to changing environmental conditions, ensuring continued efficiency and sustainability in crop cultivation.

The adoption of the Autonomous Precession Crop Planting Robot represents a transformative shift towards smart, data-driven farming practices By harnessing technology to optimize planting processes. This innovation not only promises increased productivity but also holds the potential to contribute significantly to ecological conservation efforts. As agriculture continues to evolve in the digital age, this robot stands as a beacon of progress, paving the way for a more sustainable and efficient future in farming.

II. BACKGROUND STUDY

Ivan Beloev et al. introduced a prototype of a small-scale agricultural robot designed to automate basic tasks within agricultural enterprises. The robot is conceptualized as an end-user autonomous mobile system, equipped with self-localization capabilities and capable of mapping or inspecting specific farming areas. What sets this prototype apart is its reliance on artificial intelligence (AI) algorithms for decision-making, enabling it to adapt and respond to different situations and environmental conditions. This AI-driven approach enhances the robot's autonomy, allowing it to perform tasks with precision and efficiency. The development process of the prototype involves careful consideration of various factors, including design, construction, and evaluation. It provides insights into these aspects, detailing the methodology behind the robot's creation and outlining its main characteristics. As the prototype is still in its early stages of development and evaluation, the paper also discusses potential areas for improvement and refinement.

Amir Ghalamzan et. al. developed the confluence of autonomous robots and solar energy in precision agriculture and smart farming represents a pivotal advancement in sustainable food production. With the global population on the rise and a growing demand for nutritious diets, the pressure on food production and land utilization is intensifying. However, conventional agricultural practices often compromise soil health and biodiversity, posing significant threats to future ecosystems and food security. In response to these challenges, Precision Agriculture (PA) emerges as a holistic approach aimed at optimizing resource utilization and maximizing yield through the integration of engineering, artificial intelligence

(AI), and robotics. Robotic technologies play a crucial role in realizing the potential of Precision Agriculture by enabling efficient and precise farming practices. This book chapter delves into the various robotic solutions available for precision agriculture, highlighting their importance in sustainable food production. Robotics offer the capability to automate tasks, collect data, and make informed decisions, thereby enhancing productivity while minimizing environmental impact.

Neha S. Naik et. al. proposed the emergence of robotics in the agriculture sector, particularly within the framework of precision agriculture, represents a significant technological advancement in recent years. This trend is driven by the need to streamline farming processes, conserve resources, and enhance crop productivity. The primary objective behind the automation of farming tasks is to alleviate the burden of repetitive activities while ensuring that each crop receives individualized treatment through the principles of precision farming. The design and development of agricultural robots are tailored to suit the specific requirements and challenges of the agricultural environment they operate in. This work delves into the various considerations and approaches involved in the creation of such robots, shedding light on the intricacies of their design and functionality. By addressing these considerations, researchers and engineers aim to optimize the performance and effectiveness of agricultural robots in real-world farming scenarios.

T. Hague et. al. proposed the Tillett Autonomous Robot Navigation system presents an innovative solution tailored for precision horticulture, where the need for autonomous navigation through crop fields is paramount. Unlike conventional methods reliant solely on reactive control systems, this system adopts a multi-sensor data fusion approach for enhanced reliability and accuracy. Utilizing an image analysis system capable of identifying crop row structures as a foundational component, the system integrates data from various sensors, including a solid-state compass and dead reckoning, through an extended Kalman filter. A distinguishing feature of this navigation scheme is its utilization of crop rows themselves as a navigational aid. Instead of relying on artificial navigation beacons or detailed prior maps, the system leverages the inherent structure of crop rows to guide the autonomous vehicle. Path curvature is expressed as a function of forward distance, with segments of the path aligned with crop rows. This approach not only enhances navigation accuracy but also ensures economic viability by enabling operation across diverse fields without the need for extensive prior mapping.

A.B. Nuhel et. al. introduced a PV-Powered Microcontroller-Based Agricultural Robot Utilizing GSM Technology for Crop Harvesting and Plant Watering represents an innovative integration of renewable energy, microcontroller technology, and communication systems for efficient agricultural operations. At its core, the project aims to develop an autonomous agricultural robot capable of performing essential tasks such as crop harvesting and plant watering while being powered by photovoltaic (PV) solar energy. Central to the design of this agricultural robot is the utilization of a microcontroller-based control system. Microcontrollers serve as the brains of the robot, enabling it to execute predefined tasks autonomously. By leveraging microcontroller technology, the robot can perform complex operations with precision and efficiency, thereby enhancing productivity in agricultural settings. Through meticulous design and implementation, this robot exemplifies the potential of technology to drive innovation and efficiency in agriculture, paving the way for a more sustainable and productive future in food production.

H. Suzuki et. al. proposed the development of an agricultural robot for plant detection and fertilizer dispensing represents a significant advancement in modern farming techniques, aiming to enhance efficiency, sustainability, and productivity in agriculture. This project integrates cutting-edge technology such as robotics, artificial intelligence, and precision agriculture to address key challenges faced by farmers worldwide. At the core of this project lies the utilization of robotics for plant detection. By employing various sensors such as cameras, LiDAR, and infrared sensors, the robot can accurately identify plants within the agricultural field. Machine learning algorithms are then employed to analyze the sensor data and distinguish between crops, weeds, and other elements present in the environment. This capability enables precise targeting of specific areas for fertilizer application, minimizing waste and optimizing resource utilization.

F. Nasir et. al. ensured the endeavor of developing a real-time plant recognition and crop row navigation system for an autonomous precision agricultural sprayer robot embodies a pioneering effort in modern farming methodologies. This project amalgamates state-of-the-art technologies such as computer vision, machine learning, and robotics to revolutionize crop management practices, striving towards increased efficiency, sustainability, and yield optimization in agriculture. Central to this project is the implementation of real-time plant recognition using advanced computer vision techniques. By integrating high-resolution cameras and image processing algorithms, the autonomous robot can swiftly and accurately identify various plant species within the agricultural field. This capability enables precise targeting of crops for pesticide or herbicide application, minimizing the risk of damage to non-target plants and enhancing the efficacy of pest management strategies.

W. Winterhalter et. al. proposed the project focusing on crop row detection on tiny plants with the Pattern Hough Transform marks a significant advancement in precision agriculture, particularly for crops at early growth stages. This innovative approach utilizes the Pattern Hough Transform, a variant of the traditional through Transform algorithm, to accurately identify crop rows amidst the challenging conditions posed by small plant sizes and dense vegetation. Central to this project is the application of computer vision techniques to analyze images captured in agricultural fields. By leveraging the Pattern Hough Transform, the algorithm can effectively detect the patterns characteristic of crop rows, even when plants are small and closely spaced. This capability enables farmers to precisely navigate automated farming equipment, ensuring optimal placement of seeds, fertilizers, and other inputs.

A. J. O. Ahmed et. al. invented the project on real-time agricultural monitoring with Agrobot introduces an innovative solution using Raspberry Pi and YOLO (You Only Look Once) for efficient and comprehensive monitoring of agricultural fields. Leveraging the capabilities of Raspberry Pi as a low-cost computing platform and YOLO as a powerful object detection algorithm, Agrobot enables farmers to monitor their fields in real-time, facilitating timely interventions and decision-making. At the heart of this project is the integration of Raspberry Pi, a versatile and cost-effective single-board computer, with YOLO, a state-of-the-art deep learning algorithm for object detection. By harnessing the computational power of Raspberry Pi and the efficiency of YOLO, Agrobot can rapidly analyze live video feeds from cameras installed in the agricultural field, detecting and identifying various objects such as crops, weeds, pests, and other elements of interest.

Z. Al-Mashhadani and J. -H. Park proposed the development of an autonomous agricultural monitoring robot signifies a pioneering leap towards efficient smart farming practices. This project integrates cutting-edge robotics, artificial intelligence, and sensor technologies to revolutionize agricultural monitoring and management processes. At its core, the autonomous robot is designed to navigate through agricultural fields independently, collecting real-time data on various parameters such as crop health, soil moisture, and environmental conditions. One of the key features of this project is the robot's autonomy, enabled by advanced navigation systems and machine learning algorithms. Equipped with GPS, LiDAR, and inertial sensors, the robot can navigate through the field with precision, avoiding obstacles and adapting to terrain variations. This autonomy reduces the need for manual intervention, thereby saving time and labor while ensuring comprehensive field coverage. Furthermore, the robot's sensor suite includes cameras, multispectral sensors, and other remote sensing devices, allowing for detailed monitoring of crop health and growth dynamics.

III. METHODOLOGY

The development of an autonomous crop-planting robot represents a significant stride in agricultural automation. Constructed primarily from commercial plywood, this robot integrates cutting-edge technology to streamline planting processes and enhance agricultural efficiency. Central to its operation are two controllers, one serving as a transmitter and the other as a receiver, facilitating seamless communication between the various components via WiFi connectivity. At the heart of the robot lies the Node MCU, a versatile microcontroller tasked with receiving sensor data from an array of environmental monitoring devices. These include a pH sensor for assessing water quality, a DHT22 sensor for monitoring internal battery temperature and humidity, an ultrasonic sensor for obstacle detection, and a soil moisture sensor for evaluating soil hydration levels. This comprehensive suite of sensors provides real-time insights into crucial environmental factors throughout the planting process. Driving the robot's locomotion are four DC motors strategically positioned as wheels, allowing for smooth and agile movement across agricultural terrain. Additionally, a sophisticated 5-degree-of-freedom robotic arm is seamlessly integrated into the system, enabling precise picking and planting of crops with optimal efficiency. Control of both the motors and the robotic arm is facilitated through virtual pins within the Blynk application, providing a user-friendly interface for operation.

Through the Blynk app, users can trigger specific actions by activating virtual pins, which in turn generate PWM signals to initiate motor rotation or robotic arm movement. This intuitive control mechanism empowers operators to execute planting tasks with precision and ease. Furthermore, the incorporation of a camera module further enhances the robot's capabilities, providing real-time visual feedback of the agricultural field for improved monitoring and decision-making.

Despite its advanced automation capabilities, the robot is intentionally designed as semi-automated to mitigate potential risks associated with signal loss or delayed response times in fully automated systems. This cautious approach ensures reliability and safety throughout the planting process, prioritizing the successful execution of agricultural tasks while minimizing the likelihood of errors or malfunctions. Throughout the operation, sensor data is continuously collected and transmitted to Thing Speak via IoT for comprehensive analysis. At the conclusion of the planting process, this data can be visualized through 2D graphs, providing valuable insights into environmental conditions and crop performance. By leveraging technology to optimize planting processes, this autonomous crop-planting robot represents a pivotal advancement in modern agriculture, paving the way for increased efficiency, sustainability, and productivity in crop production. The overall block diagram of the proposed work is shown in Fig. 1.

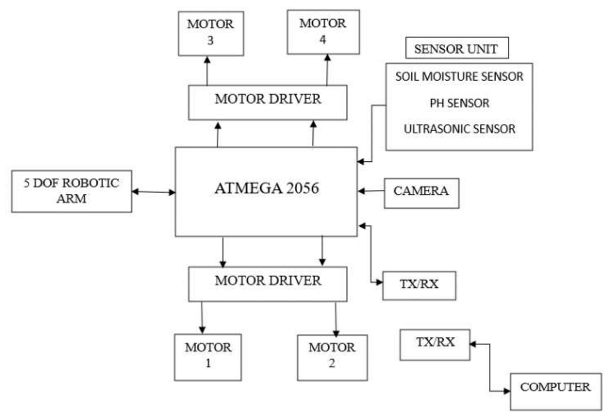

Fig 1. Overall Block Diagram

ATmega microcontroller is the heart of Autonomous Precession Crop Planting Robot as it controls all its advanced functionality. The ATmega MCU acts like the robot's brain, providing a simple connection between main sensors as soil moisture and temperature or even GPS position. The ATmega, with its powerful computational capabilities and embedded AI algorithms processes these sensors which provide real-time environmental data. This makes it possible for the robot to navigate itself around fields and able to find locations suitable for seed planting with respect of soil conditions or crop requirements. In addition to a user-friendly design, the ATmega controlled seed placement depth and spacing - ensuring crops can grow to their maximum potential with minimal resource usage.

A. HARDWARE SETUP OF THE BOT

Fig 2 Represents the Incorporating a robotic arm into this bot enables it to autonomously harvest plants and reposition them into the soil. This innovative system streamlines agricultural processes, enhancing efficiency and reducing manual labor. The robotic arm utilizes advanced sensors and algorithms to identify ripe produce and carefully grasp it without damaging the plant. Once picked, the arm precisely places the plant into the soil at the optimal depth for continued growth.

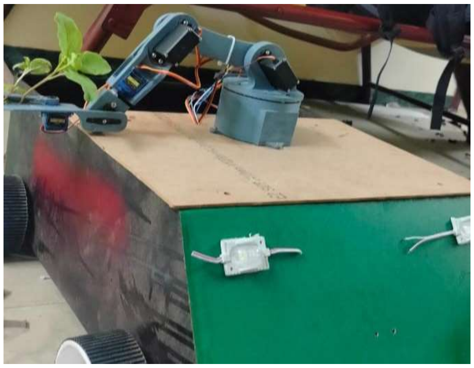

Fig 2 Robotic arm connected with bot

B. DESIGN OF 5DoF ROBOTIC ARM

Fig 3 shows the design of a robotic arm using Solid works involves several key steps to ensure functionality and efficiency. Beginning with conceptualization, engineers outline the arm's intended purpose, range of motion, and payload capacity. This phase often involves sketching and brainstorming to visualize the final product. Next, Solid works software is utilized to create detailed 3D models of each component, including joints, actuators, and end effectors. Precise measurements and tolerances are crucial to ensure seamless integration and movement. Iterative testing and analysis are then conducted within Solid works to refine the design, addressing any structural weaknesses or performance issues. Finally, once the design meets specifications and requirements, it can be manufactured and assembled for real-world applications.

Fig 3 Solid work design of robotic arm

C. SENSOR'S DATA VIEWED IN THINK SPEEK

Fig 4 shows the NodeMCU microcontroller is effectively employed to receive real-time sensor data, sensors like DHT 22 Temperature sensor, Capacitive soil moisture sensor and Ultrasonic sensor, which is then seamlessly transmitted to the Thing speak platform through the Internet of Things (IoT) connectivity. This process initiates with the sensor data acquisition, where the NodeMCU gathers information from the designated sensors. Subsequently, the NodeMCU utilizes its connectivity features to transmit this data to the Thing speak platform, enabling remote monitoring and analysis. The integration of NodeMCU with Thing speak ensures a smooth and efficient flow of live sensor data, facilitating real-time insights and decision-making. Throughout the operation, the sensor data is continuously plotted, allowing for visualization and analysis of trends or anomalies. This seamless flow of information persists until the conclusion of the NodeMCU's power supply, ensuring uninterrupted monitoring and data transmission.

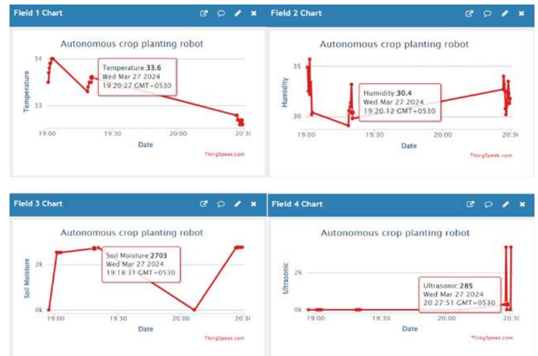

Fig 4 Live sensor data's

D. ARM CONTROL USING BLYNK APP

Fig 5 shows the robotic arm's functionalities can now be seamlessly controlled through the Blynk app, marking a significant advancement in remote operation and accessibility. This integration allows users to manipulate the robotic arm's movements, such as grasping, lifting, and rotating, with the convenience of their smartphones or tablets. Through the intuitive interface of the Blynk app, users can send commands to the robotic arm effortlessly, enabling precise and efficient control over various tasks and applications. This innovation not only enhances user experience but also opens up new possibilities for automation and remote operations in diverse fields, ranging from manufacturing and logistics to healthcare and education.

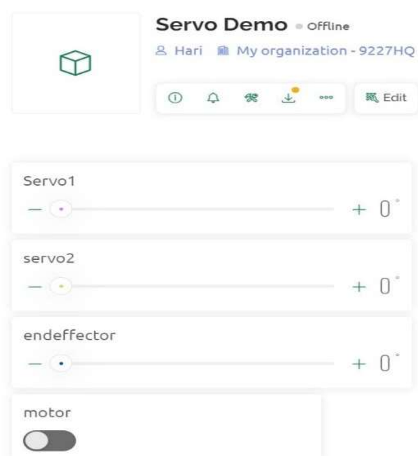

Fig 5 Robotic arm is controlled in blynk app

E. BOT CONTROLLING

Fig 6 shows the controlling of bot After planting crops in rows, controlling a bot to move both forward and in reverse direction involves utilizing a combination of programming and mechanical systems. The bot needs to be equipped with sensors to detect the end of each row and to navigate between them. Programming algorithms are employed to dictate the bot's movements, ensuring precise control and coordination. This includes commands for forward movement along the rows, as well as reverse movements to backtrack for the next row. Additionally, mechanical components such as motors and actuators are utilized to physically drive the bot in the desired directions. By integrating these elements seamlessly, the bot can efficiently navigate the field, planting crops row by row without missing any areas. This approach requires careful synchronization of the bot's movements with the spacing of the crops and the layout of the field to optimize efficiency and accuracy while minimizing the risk of errors.

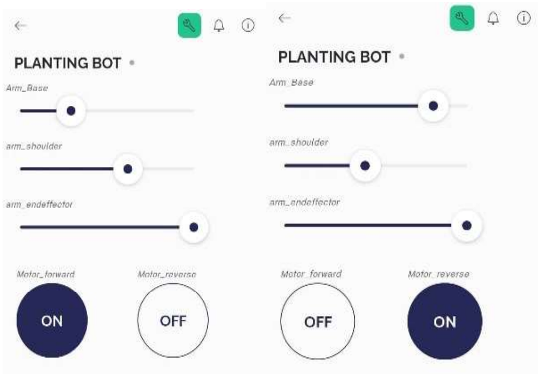

Fig 6 Controlling of bot in forward and reverse mode

F. STRUCTURAL DESIGNING OF BOT

Fig 7 shows the use of Unity software for the structural design of a crop planting bot involves leveraging its versatile capabilities for 3D modeling and simulation. Engineers employ Unity's intuitive interface and powerful tools to create detailed virtual representations of the bot's components, including its chassis, arms, planting mechanisms, and sensors. By accurately modeling each part, they can analyze the bot's structural integrity, assess its functionality, and optimize its design for efficiency and durability. Unity's physics engine enables engineers to simulate real-world interactions, such as the bot's movements across varying terrain and the forces exerted on its components during operation. This allows for thorough testing and refinement before physical prototyping, reducing development time and costs. Additionally, Unity's compatibility with various hardware platforms facilitates seamless integration with the bot's control systems, ensuring smooth communication between the virtual design and the physical implementation. Overall, Unity serves as a powerful tool for engineers to design, analyze, and refine the structural aspects of crop planting bots, enabling the creation of robust and effective agricultural machinery.

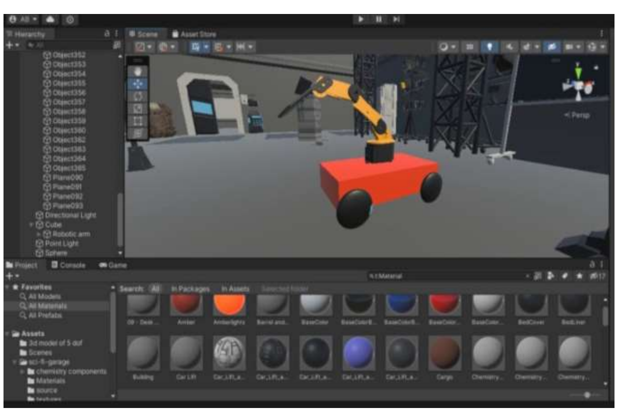

Fig 7 Structural design of the bot

IV. RESULT

The autonomous crop-planting robot is an innovative solution for modern agriculture that combines various hardware technologies to achieve efficient and accurate crop planting. The use of WiFi communication and IoT enables real-time monitoring of environmental factors, such as soil moisture, temperature, and humidity, allowing farmers to optimize their crop planting strategies and improve overall crop yield. The use of a 5 DOF robotic arm and ultrasonic sensor enables precise picking and planting of plants, reducing the risk of damage to the plants and ensuring accurate placement in the soil. The addition of a camera module provides enhanced vision capabilities, allowing farmers to monitor the agricultural field and ensure optimal planting conditions. The use of NodeMCU as the primary controller and Blynk application for motor and robotic arm control provides a user-friendly interface for farmers, enabling easy operation and customization of the robot. The pH sensor, DHT22 sensor, and soil moisture sensor provide important information about the soil and environmental conditions, ensuring optimal performance and longevity of the robot. The semi-automated nature of the robot ensures efficient and accurate crop planting while minimizing the risk of signal loss or increased response time. Overall, the autonomous crop-planting robot has the potential to revolutionize the agricultural industry and provide a more sustainable and efficient approach to crop production.

Several factors to be considered when deciding on the appropriate approach to researching the Autonomous Precession Crop Planting Robot. The first is the foundation of sensor systems and AI algorithms in terms of reliability, accuracy. It is essential for the sensors to be able to capture soil composition, moisture and nutrient concentration. Similarly, the AI algorithms must be able to process this data immediately and turn it into accurate decisions on where best to plant seeds in a field, how deep should those seeds go down and what is their optimal spacing. These components are key to maximizing crop yields while optimizing resource use, support and maintaining sustainability in agriculture.

Secondly, the robot's going to be applied in real-life agricultural conditions and its adaptation to this specific case should be accessed both on a scale and a practical point of view. When technologies are evaluated they must be looked at in their development of field sizes, crop types, or tech to be included in the existing innovation process in agritech. The long-term usage of the robot and the picturesque and other aspects of the physical environment (e.g., climate, geography, and flora) are the main considerations. These functions of the robot can be thought both from the point of view of production costs and productivity as they may have increased costs at the implementation stage. Nonetheless, if the robot performs as per requirements, the overall cost of operation will most likely be significantly decreased. Rather than having the text with a few words which the language model has not been trained on, writing it in such a way that the language model can learn the language better should have a high quality content ideally.

REFERENCES

[1] Ivan Beloev,Diyana Kyuchukova,Georgi Georgiev,G.V. Hristov, "rtificial Intelligence-Driven Autonomous Robot for Precision Agriculture" Acta Technologica Agriculturae, 24(1), pp.48-54, 2021.

[2] Amir Ghalamzan, Gautham P Das, Iain Gould, Payam Zarafshan, "Autonomous robots and solar energy for precision agriculture and

smart farming", Solar Energy Advancements in Agriculture and Food Production Systems, Elsevier, 2023.

[3] N. S. Naik, V. V. Shete and S. R. Danve, "Precision agriculture robot for seeding function," *2016 International Conference on Inventive Computation Technologies (ICICT)*, India, 2016.

[4] T. Hague, J. A. Marchant and N. D. Tillett, "Autonomous robot navigation for precision horticulture," Proceedings of International Conference on Robotics and Automation, USA, 2018

[5] A. K. Nuhel, M. M. Sazid, D. Paul, E. Hasan, P. H. Roy and F. P. Sinojiya, "A PV-Powered Microcontroller-Based Agricultural Robot Utilizing GSM Technology for Crop Harvesting and Plant Watering," 2023 IEEE International Students' Conference on Electrical, Electronics and Computer Science (SCEECS), India, 2023.

[6] H. Suzuki, R. Osawa, H. Saegusa, S. -i. Kaneko and G. Capi, "Development of Agriculture Robot for Plant Detection and Fertilizer Dispense," *2022 2nd International Conference on Image Processing and Robotics (ICIPRob)*, Sri Lanka, 2022.

[7] F. Nasir, M. Haris, B. Khan, M. Tufail, M. T. Khan and Z. Dong, "Real-Time Plant Recognition and Crop Row Navigation for Autonomous Precision Agricultural Sprayer Robot" 2023 International Conference on Robotics and Automation in Industry (ICRAI)*, Pakistan, 2023.*

[8] W. Winterhalter, F. V. Fleckenstein, C. Dornhege and W. Burgard, "Crop Row Detection on Tiny Plants With the Pattern Hough Transform," IEEE Robotics and Automation Letters, *2018.*

[9] A. J. O. Ahmed, A. Babiker, A. Elhag and M. Drar, "Real-Time Agricultural Monitoring with Agrobot: A Raspberry Pi and YOLO Based Solution," 2023 International Conference on Computer and Applications (ICCA), 2023

[10] Z. Al-Mashhadani and J. -H. Park, "Autonomous Agricultural Monitoring Robot for Efficient Smart Farming," *2023* 23rd International Conference on Control, Automation and Systems (ICCAS)*, Korea, 2023.*