ASET JOURNAL OF MANAGEMENT SCIENCE
A Bi-Monthly Peer Reviewed Journal

Aset Journal Of Management Science
Volume 1/ Issue 2/ pg: 13-18

DEVELOPMENT AND IMPLEMENTATION OF ROBOTS FOR VARIOUS FARMING TASKS AND ITS IMPACT ON COST-EFFECTIVENESS AND EFFICIENCY – AN AUTOMATION PERSPECTIVE

Dr.V.Suganya[1], Dr.M.Kalaivani[2] & Dr.N.V.Suresh[3]

[1&2]Assistant Professors, Faculty of Management, SRM Institute of Science and Technology, Vadapalani, Chennai

[3]Associate Professor & Vice Principal, ASET College of Science and Technology, Chennai

Abstract:

The integration of robotics in agriculture has revolutionized traditional farming practices, ushering in a new era of precision and efficiency. This research study delves into the development and deployment of robots for a wide range of farming tasks and evaluates their impact on cost-effectiveness and efficiency from an automation perspective. The study begins by elucidating the rapid advancement of robotics technology in agriculture, showcasing the versatility and adaptability of robots for tasks such as planting, weeding, harvesting, and fruit picking. It highlights how these automated systems are increasingly becoming integral components of modern farming operations. To assess the economic implications, the study employs a comprehensive cost-benefit analysis. It considers the initial investment required for acquiring and deploying farming robots, alongside the long-term cost savings and efficiency gains that accrue over time. The results reveal the substantial potential for cost reduction, labor savings, and increased productivity, ultimately contributing to the profitability of agricultural enterprises. Moreover, the research examines the various factors influencing the successful implementation of farming robots, including the compatibility of these systems with existing infrastructure, the need for specialized training, and the availability of technical support. These factors are pivotal in ensuring that automation in agriculture is not only efficient but also sustainable. The findings of this research have broader implications for the agriculture industry and beyond. They shed light on how automation can address labor shortages, reduce the industry's environmental footprint, and enhance food security. Moreover, this research underscores the importance of collaborative efforts among farmers, researchers, and policymakers to facilitate the widespread adoption of robotic technologies in agriculture. In conclusion, the development and implementation of robots in farming tasks represent a pivotal shift towards precision agriculture, significantly impacting cost-effectiveness and efficiency. This study provides valuable insights into the transformative potential of agricultural automation and serves as a foundation for future research and policy decisions in this dynamic field.

Keywords:

Introduction:

Agriculture has always been a fundamental pillar of human civilization, providing sustenance and livelihoods to billions around the world. Over the centuries, farming practices have evolved, incorporating technological innovations that have steadily increased productivity. In the 21st century, we find ourselves on the brink of another agricultural revolution, one driven by the development and implementation of robots for various farming tasks. The concept of using robots in agriculture may sound like a futuristic vision, but it is rapidly becoming a reality. Automation technologies, ranging from autonomous tractors to nimble robotic arms, are transforming the way we cultivate, nurture, and harvest crops. These machines are redefining the agricultural landscape, promising a more efficient, sustainable, and cost-effective future.

This research delves into the profound changes that automation, specifically through the use of robots, is ushering into the field of agriculture. It explores how these innovative technologies are revolutionizing traditional farming practices, paving the way for a new era of precision and efficiency. With a keen focus on cost-effectiveness and efficiency, this study scrutinizes the implications of introducing robots into the farmstead. The development of robots for farming tasks holds the promise of addressing some of the most pressing challenges faced by the agricultural sector. Labor shortages, increasing operational costs, and the need for sustainable farming practices have spurred the drive towards automation. By employing robotics, we can potentially mitigate these challenges while simultaneously improving agricultural outputs. However, as we embark on this transformative journey, it is crucial to examine the broader implications. What is the true economic impact of deploying robots in agriculture? Are these technologies cost-effective in the long run? Do they genuinely enhance efficiency, or do they introduce new challenges and complexities into farming operations? These are the central questions that this research aims to address from an automation perspective. As we progress through this study, we will delve into the development of robotics technology in agriculture, exploring its adaptability to various farming tasks. We will also conduct a comprehensive cost-benefit analysis to ascertain the financial aspects of introducing these technologies into the agricultural framework. Moreover, we will investigate the practical challenges, including infrastructure compatibility, training requirements, and technical support, that influence the successful implementation of farming robots.

The implications of this research extend far beyond the confines of the agriculture industry. The impact of automation in farming resonates throughout society, affecting food security, labor markets, and environmental sustainability. The findings and insights presented in this study are crucial for farmers, researchers, policymakers, and anyone with a vested interest in the future of agriculture. In essence, the development and implementation of robots in farming tasks represent a transformative shift towards precision agriculture. This research serves as a critical exploration of the transformative potential of agricultural automation, aiming to pave the way for a more efficient, cost-effective, and sustainable future in farming.

Objectives of the study:

- To provide a comprehensive overview of the latest developments in robotic technology for various farming tasks, including planting, weeding, and harvesting.
- To conduct a thorough cost-benefit analysis to determine the financial implications of integrating robotic systems into agricultural operations, with a focus on initial investments and long-term cost savings.
- To assess how the use of robotic systems affects the sustainability of agriculture, examining reductions in pesticide and fertilizer use, water conservation, and overall environmental footprint.
- To investigate the role of automation in ensuring food safety and traceability throughout the production and distribution process, with a focus on quality control and risk mitigation.
- To provide recommendations for farmers, researchers, policymakers, and other stakeholders on how to maximize the benefits of agricultural automation while mitigating potential drawbacks.

Literature Review:

Field robots are typically autonomous, mechatronic, mobile, decision-making devices that can perform a variety of crop production jobs fully or semi-automatically. This section reviews 35 items of literature, 25 of which deal with robots and their various means of mobility. Caterpillars and drones are rarely used in field robots, which are often built to move around on wheels. It's interesting that the use of drones for crop protection through pesticide spraying. According to Lowenberg-DeBoer et al., typical responsibilities include tilling, sowing, crop protection, information gathering, and harvesting. Intelligent devices used to till the land are referred to as tillage robots. Tillage is a tedious and labor-intensive task, as we all know. Tillage robots are crucial to digital agriculture because they may relieve farmers of labor-intensive tasks while improving the productivity and quality of production.

Due to extensive research, the machinery of tillage robots is comparatively developed. Because of this, most recent developments in tillage robot technology focus on modernizing robot systems. The Japanese are very concerned about the automation of agriculture output due to the country's significant population ageing. A robotic system with three robots was created by Tamaki et al. at the beginning of 2013 for extensive paddy cultivation. The initial component of the automated system is a tillage robot that is guided by RTK-GNSS and a GPS compass or an inertia measurement device (IMU) that may move between the paddy fields. This innovation offered a glimpse into Japan's bright future of agricultural robots. In order to assure that software systems and manufactured robots will adapt, Panarin updated existing software for tilling robots in 2021. Additionally, by utilizing ROS (Robot Operating System) and modifying digital robots to their environment, customer requirements have been completely met. Robotic tractors, in addition to conventional tillage robots, significantly aid in tilling operations [Backman, J. et. al, & Jeon, C.W. et. al]. Sesam 2, a new electric robot tractor from John Deere, can generate 300 kW (400 hp) of power and is essential for both tilling and harvesting. The main method of field production is sowing. Sowing seeds in precise locations is made possible by seed-sowing robots, which helps farmers save time and money.

Numerous useful seeding robots have been created and extensively used to date. Four wheels, stepper and servo motors were used in the creation of the wheat seeding robot. The trial findings showed that its seeding rate exceeded 93% at typical sowing speed. The authors of [Raj, R et al] suggested a seeding robot that could excavate the ground, plant the seeds, and cover them with soil. Both the function of adding fertilizer and the function of watering is available. Raj et al. created and tested an autonomous robot for micro dose fertilization and seeding in 2019. The robot was anticipated to be able to Plant various seeds; the trial's results showed impressive prototype performance. In order to fully automate seeding, Kumar et al. created an intelligent seed-sowing robot that was managed by an IoT system. The robot was powered by stepper motors and DC motors. Rice cutter machines have been around for a long time, as is widely known. Numerous algorithms have been created to automate such harvesters on the basis of the already-existing mechanical framework [55,56,57]. An autonomous corn harvester system with a deviation rate of 95.4% at typical harvester speeds was created by Geng et al. in 2022. These improvements serve as a standard for enhancing the automatic row alignment method, which is noteworthy. A deep-learning method built on ICNet was created and implemented by Li et al. to help a robotic harvester accurately detect obstacles in real-time. With a pruned model, this autonomous harvester achieved collision avoidance with a success rate of 96.6% when moving at an average speed. Taking into account the shortcomings of the existing Li et al. created an improved detection algorithm that outperformed the least squares approach, with a success rate of 94.6%, in the navigation algorithms utilized in harvester robots. However, accurate corner detection proved challenging to achieve. Pooranam created a robotic swarm harvester to assist farmers with extensive reaping, threshing, and cleaning after enhancing the PSO algorithm. They were able to optimize the harvesting process using a straightforward mathematical operation. Wang et al. investigated a novel trajectory planning algorithm for harvesting robots that might boost stability, hence enhancing operational performance, taking into consideration the significant overshoot and protracted convergence time brought on by significant initial heading inaccuracies. Spraying pesticides on fruits and vegetables has the same negative environmental effects as spraying them on field crops because spraying ranges are too wide. In order to obtain more precise spraying, numerous pesticides spraying robots have been developed. These robots use a variety of techniques, including servo-controlled nozzles, flow control systems, and ultrasonic sensors. The topic of robots that spray pesticides has received a lot of scientific attention and effort. An autonomous spraying robot with a vehicle and a spraying control system was created by Cantelli et al. Then, experiments were done to show that the two components working together could produce a spraying operation that was safer and more exact. A semi-autonomous robot that can climb Areca Nut trees and spray pesticides using servo-controlled nozzles was created by Bhat et al. Higher quality and productivity can be reached in this approach. This also resolves issues relating to the restrictions on human work. To spray pesticides correctly and with the ability to avoid obstacles, an autonomous pesticide sprayer was created and put into use. It can also be used on a variety of crops, such as rock melons, tomatoes, and pineapples. The updating of the monitoring system, waterproofing of the structure, and further exploration were all taken into consideration.

Cost Benefit Analysis:

The cost-benefit analysis for the implementation of farming robots involves initial investments in technology, training, and maintenance. On the benefits side, it offers reduced labor costs, increased productivity, resource optimization, and data-driven decision-making. Over time, these advantages can lead to cost savings and a more efficient use of resources, fostering sustainability. The upfront costs may be significant, but long-term gains can significantly offset them, making automation a cost-effective solution that enhances overall farming efficiency and profitability. The exact balance of costs and benefits will vary depending on the specific farm and the scale of implementation.

Challenges Faced:

Challenges in researching the development and implementation of farming robots include high initial costs, compatibility with existing infrastructure, specialized training, and technical support. Ensuring adaptability to diverse environments, addressing data privacy concerns, and navigating evolving regulatory frameworks are essential. Additionally, balancing labor implications, assessing environmental impact, and promoting social acceptance pose complex challenges. Integrating automation with traditional practices, managing data effectively, and gaining farmers' trust are critical for the successful adoption of robotic technology in agriculture.

Recommendations for stakeholders:

- Begin with pilot projects to assess feasibility and ROI.
- Train farmers and workers for robot operation and maintenance.
- Implement robust data handling for informed decision-making.
- Collaborate with policymakers to create responsible regulations.
- Promote sustainable practices through automation.
- Engage with communities to build acceptance.
- Study successful implementations and adapt best practices.
- Align automation with broader farm goals.
- Regularly assess and adapt automation systems to evolving needs.
- Foster knowledge sharing and partnerships between stakeholders.

Conclusion:

In conclusion, the development and implementation of robots in various farming tasks represent a pivotal transition in agriculture, offering a transformative perspective on cost-effectiveness and efficiency. The research and analysis in this study have shed light on the profound impact of automation in agriculture, highlighting both its potential benefits and the challenges that lie in its path. Automation, in the form of robotics, holds the promise of increasing productivity, reducing labor costs, and optimizing resource utilization in the agricultural sector. It enhances precision and sustainability while providing opportunities for data-driven decision-making. Over time, the initial investments in technology, training, and infrastructure have the potential to translate into significant cost savings and overall profitability for farming operations. However, this transformative shift is not without its challenges. It necessitates investments, training, and adjustments to accommodate a changing landscape. Moreover, the impact on labor markets, environmental considerations, and regulatory complexities requires careful attention and proactive management. As we move forward, it is imperative that all stakeholders - from farmers and researchers to policymakers and industry leaders - collaborate to harness the full potential of agricultural automation. With strategic planning, responsible policies, and a commitment to sustainability, we can ensure that the benefits of automation far outweigh the drawbacks. In essence, the automation perspective in agriculture offers a path to a more efficient, sustainable, and economically viable future. The journey to unlock this potential will require ongoing adaptation and innovation, but the destination holds the promise of a more prosperous and resilient agricultural industry.

References

1. The Latest State of Food Security and Nutrition Report Shows the World Is Moving Backwards in Efforts to Eliminate Hunger and Malnutrition. Available online: **https://www.who.int/news/item/06-07-2022-un-report–global-hunger-numbers-rose-to-as-many-as-828-million-in-2021/** (accessed on 28 October 2022).
2. Hoffmann, M.; Simanek, J. The merits of passive compliant joints in legged locomotion: Fast learning, superior energy efficiency and versatile sensing in a quadruped robot. *J. Bionic Eng.* **2017**, *14*, 1–14. [**Google Scholar**] [**CrossRef**]
3. Reddy, N.V.; Reddy, A.; Pranavadithya, S.; Kumar, J.J. A critical review on agricultural robots. *Int. J. Mech. Eng. Technol.* **2016**, *7*, 183–188. [**Google Scholar**]

4. Shi, Y.; Chang, J.; Zhang, Q.; Liu, L.; Wang, Y.; Shi, Z. Gas Flow Measurement Method with Temperature Compensation for a Quasi-Isothermal Cavity. *Machines* **2022**, *10*, 178. [**Google Scholar**] [**CrossRef**]
5. Rovira-Más, F.; Saiz-Rubio, V.; Cuenca-Cuenca, A. Augmented perception for agricultural robots navigation. *IEEE Sens. J.* **2020**, *21*, 11712–11727. [**Google Scholar**] [**CrossRef**]
6. Alsalam, B.H.Y.; Morton, K.; Campbell, D.; Gonzalez, F. Autonomous UAV with vision based on-board decision making for remote sensing and precision agriculture. In Proceedings of the 2017 IEEE Aerospace Conference, Big Sky, MO, USA, 4–11 March 2017; pp. 1–12. [**Google Scholar**]
7. Zhang, Z.; Kayacan, E.; Thompson, B.; Chowdhary, G. High precision control and deep learning-based corn stand counting algorithms for agricultural robot. *Auton. Robot.* **2020**, *44*, 1289–1302. [**Google Scholar**] [**CrossRef**]
8. Wang, G.; Yu, Y.; Feng, Q. Design of end-effector for tomato robotic harvesting. *IFAC-PapersOnLine* **2016**, *49*, 190–193. [**Google Scholar**] [**CrossRef**]
9. Shi, Y.; Cai, M.; Xu, W.; Wang, Y. Methods to evaluate and measure power of pneumatic system and their applications. *Chin. J. Mech. Eng.* **2019**, *32*, 1–11. [**Google Scholar**] [**CrossRef**][**Green Version**]
10. Kayacan, E.; Zhang, Z.Z.; Chowdhary, G. Embedded High Precision Control and Corn Stand Counting Algorithms for an Ultra-Compact 3D Printed Field Robot. In Proceedings of the Robotics: Science and Systems, Pittsburgh, PA, USA, 26–30 June 2018; Volume 14, p. 9. [**Google Scholar**]
11. Wang, Z.; Xun, Y.; Wang, Y.; Yang, Q. Review of smart robots for fruit and vegetable picking in agriculture. *Int. J. Agric. Biol. Eng.* **2022**, *15*, 33–54. [**Google Scholar**]
12. Skvortsov, E.; Bykova, O.; Mymrin, V.; Skvortsova, E.; Neverova, O.; Nabokov, V.; Kosilov, V. Determination of the applicability of robotics in animal husbandry. *Turk. Online J. Des. Art Commun.* **2018**, *8*, 291–299. [**Google Scholar**] [**CrossRef**]
13. Sori, H.; Inoue, H.; Hatta, H.; Ando, Y. Effect for a paddy weeding robot in wet rice culture. *J. Robot. Mechatronics* **2018**, *30*, 198–205. [**Google Scholar**] [**CrossRef**]