THE SCIENCE WORLD
A Monthly e Magazine
ISSN:2583-2212
Popular Article
August, 2023; 3(08), 1996-2000

Robotic Technologies: Tools for advance vegetable productions

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https://doi.org/10.5281/zenodo.8253248

Abstract

Robotic technology has revolutionized various industries, and the field of vegetable production is no exception. With the increasing demand for fresh and high-quality vegetables, farmers are turning to robots to improve efficiency and productivity in their operations. One of the main advantages of using robotic technology in vegetable production is the ability to automate tedious and repetitive tasks. Robots can be programmed to perform activities such as planting, watering, and harvesting, reducing the need for manual labor. This not only saves time but also minimizes the risk of human error, ensuring consistent and precise results. Moreover, robots can operate in a controlled and optimized environment, leading to improved crop yields. By utilizing sensors and artificial intelligence, they can monitor and adjust factors such as temperature, humidity, and light intensity, creating the ideal conditions for plant growth. This level of precision allows farmers to maximize their production and minimize waste. Another benefit of robotic technology is its potential to reduce the use of pesticides and fertilizers. Robots equipped with advanced imaging systems can detect pests and diseases at an early stage, enabling targeted treatment. This targeted approach reduces the amount of chemicals needed, making vegetable production more environmentally friendly and sustainable.
Keywords: robots, drones, vegetable crops, precision farming and AI

Introduction

In recent years, the agricultural industry has witnessed a significant transformation with the integration of advanced technologies. One such technology that has gained immense popularity is robotics. Robotic technologies have revolutionized various sectors, and vegetable production is no exception. With the increasing demand for sustainable and efficient farming practices, the adoption of robotics in vegetable production has proven to be a game-changer (James *et al.*, 2020).

Components

1. **Robotic arms:** These are used for tasks such as harvesting, pruning, and planting. They are equipped with sensors and grippers to handle delicate crops.
2. **Vision systems:** These are used to identify and locate vegetables for harvesting. They can detect ripeness, size, and color to ensure accurate and efficient harvesting.

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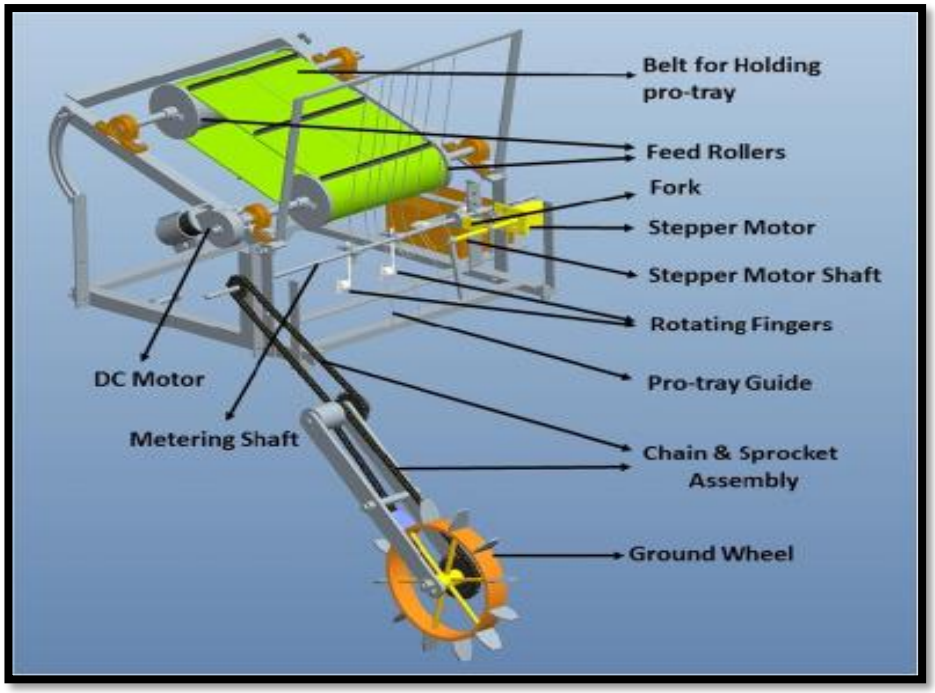
Published: **15.08.2023**

3. **Sensors:** These are used to collect data on soil moisture, temperature, and nutrient levels. This information is used to optimize irrigation and fertilization, leading to improved crop health and yield.
4. **Autonomous navigation:** Robots are equipped with sensors, cameras, and algorithms to navigate through fields and avoid obstacles. This allows them to move autonomously and efficiently perform tasks.
5. **Data analytics:** Robotic technologies generate a vast amount of data. Data analytics tools are used to process and analyze this data, providing insights on crop health, yield prediction, and resource management.

Robotic Technologies in Vegetable Productions

1. Automated Seeding and Transplanting Systems

Automated seeding and transplanting systems have emerged as a significant breakthrough in vegetable production. These systems utilize robots equipped with precise sensors and algorithms to efficiently plant seeds or transplant seedlings. By automating these labor-intensive tasks, farmers can save time, reduce costs, and ensure uniformity in plant spacing, resulting in higher crop yields. Additionally, these systems can operate continuously, enabling farmers to increase their production capacity and meet the growing demand for vegetables (Khadatkar *et al.*, 2018).



2. Automated Weeding Systems

Weeding is crucial aspects of vegetable production, as invasive plants can significantly impact on crop growth. Robotic technologies, such as automated weeding systems, offer a sustainable and efficient solution. These robots can identify and remove weeds without the need for harmful chemicals, reducing the environmental impact of farming practices. Moreover, these systems can

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target specific areas, minimizing crop damage and increasing overall productivity (Steven *et al.*, 2016).

3. Harvesting and Sorting Robots

One of the most labor-intensive and time-consuming tasks in vegetable production is harvesting and sorting. Robotic technologies have made significant strides in automating these processes, resulting in increased efficiency and reduced labor costs. Harvesting robots equipped with advanced sensors and algorithms can identify ripe vegetables, pick them gently without causing damage, and sort them based on size, shape, and quality. This level of precision ensures that only the highest quality vegetables reach the market, enhancing the reputation of farmers and improving consumer satisfaction (Bachche, 2015).

4. Grafting robots

The first commercial model of a grafting robot (GR800 series, Iseki & Co. Ltd., Matsuyama, Japan) became available for cucurbits back in 1993. Since then, semi- or fully-automated grafting robots were invented by several agricultural machine industries and several commercial models are available in East Asia, Europe, and more recently in the U.S. Semi-automated grafting robots generally graft at a speed of 600-800 grafts per hour (speed equivalent of 5-6 skilled workers for cucurbit, and 2-3 skilled workers for tomato), but require a minimum of two workers and one trained worker to inspect the grafting quality (Kai *et al.*, 2012).

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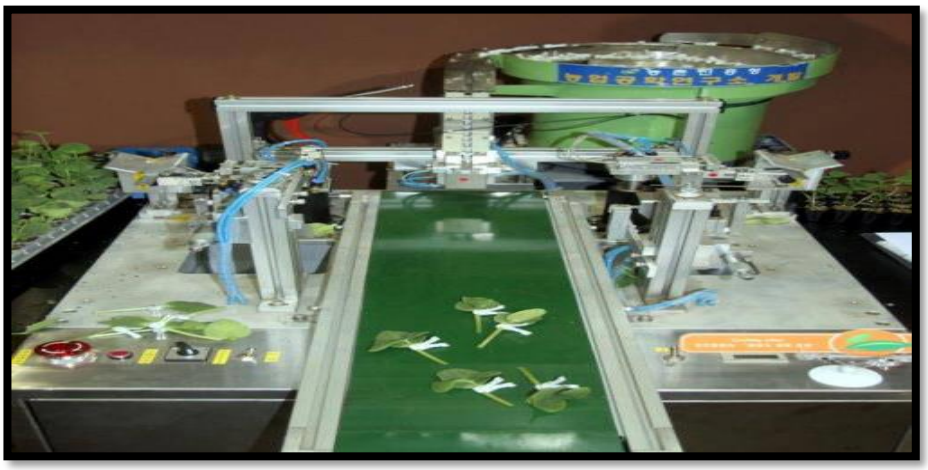

5. Drones

Drones have been increasingly used in vegetable production for various purposes, including crop monitoring, pest control, and precision agriculture. Here are some key roles of drones in vegetable production (Oksana *et al.*, 2021):

1. **Crop monitoring:** Drones equipped with high-resolution cameras and sensors can capture detailed aerial imagery of vegetable fields. This imagery can be used to monitor crop health, detect nutrient deficiencies, identify diseases or pests, and assess overall crop growth.
2. **Irrigation management:** Drones can help monitor soil moisture levels in vegetable fields by using thermal or multispectral sensors. This information can be used to optimize irrigation schedules and ensure efficient water usage, thereby improving crop yield and quality.
3. **Pest control:** Drones can be equipped with sprayers or release devices to apply pesticides or beneficial insects precisely and efficiently. This targeted approach helps reduce chemical usage, minimize environmental impact, and control pests effectively in vegetable production.
4. **Crop mapping and analysis:** Drones can create accurate 3D maps of vegetable fields using advanced imaging techniques like photogrammetry. These maps can provide valuable insights into plant density, canopy cover, and growth patterns, enabling farmers to make data-driven decisions for crop management.
5. **Precision agriculture:** By integrating drone data with other technologies like GPS and GIS, farmers can implement precision agriculture techniques. Drones can help generate prescription maps for variable rate application of fertilizers or other inputs, leading to optimized resource utilization and improved crop performance.

Benefits of Robotic Technologies in Vegetable Productions

The integration of robotic technologies in vegetable production offers numerous benefits, including (Cheng *et al.*, 2023):

1. Increased Efficiency: Robots can perform repetitive tasks with precision and speed, allowing farmers to save time and resources.

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2. Cost Reduction: By automating labor-intensive tasks, farmers can reduce their dependence on manual labor, resulting in significant cost savings.

3. Improved Quality: Robotic technologies ensure uniformity in planting, harvesting, and sorting, leading to higher-quality vegetables.

4. Environmental Sustainability: Automated weeding and pest control systems reduce the need for harmful chemicals, promoting sustainable farming practices.

Challenges

Despite the numerous benefits, the adoption of robotic technologies in vegetable production does come with its own set of challenges. The initial investment cost for implementing robotic systems can be high, making it a barrier for small-scale farmers. Additionally, the complexity of operating and maintaining these systems may require specialized knowledge and training (Cheng *et al*., 2023).

Conclusion

Robotic technologies have transformed vegetable production by automating various tasks, increasing efficiency, reducing costs, and promoting sustainable farming practices. Automated seeding and transplanting systems, weeding and pest control robots, and harvesting and sorting robots have revolutionized the way vegetables are produced. While challenges exist, the future prospects for robotic technologies in vegetable production are bright. As technology continues to evolve, the integration of robotics will become more accessible and beneficial to farmers worldwide.

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