Chapter 19

Automation and Robotics in Agriculture: The Emergence of Smart Farms

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Abstract

The article discusses Agriculture 4.0, a concept of intelligent farming, as well as important technology and applications. It emphasizes how crucial modern infrastructures, cloud computing, and automated machinery are to streamlining daily operations and figuring out input material requirements. This review paper explores the use of agricultural robotic systems in tasks like land preparation, sowing, planting, treatment, harvesting, yield estimation, and phenotyping. The challenges that ground robots encounter in agricultural environments are discussed, including the wide range of environmental factors, complex plant canopy systems, and biological differences between species. It examines at both possible future paths and current approaches. Additionally, it examines the most recent developments in precision agriculture's utilization of mobile robots, with an emphasis on technologies for soil, crop, and field monitoring. It includes case analysis and illustrates important robotic solutions, especially land-based robots. The analysis emphasizes how other agricultural operations are increasingly being automated, with a rising concentration on vision and cloud point identification. The integration of cloud computing with precision agriculture and intelligent farming techniques is covered in this study, along with how agriculture robots and automation systems can overcome computation, retention, and storage constraints.

Keywords

Agricultural Robotics, Autonomous Robots, Autonomous Weed Control, Intelligent Farming, Robotic Harvesters

1. Introduction

Precision agriculture, that employs robotic systems to automate agricultural chores, emerged as a result of the demand for innovative technologies to provide a high-quality food supply in response to the

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world's population expansion [1]. Agriculture is growing more and more reliant on robotics and artificial intelligence (AI), with deep learning approaches like convolutional neural networks optimizing workflows. These models are able to count fruits, identify crops and plants, detect and categorize plant diseases, and differentiate between weeds and crops [2]. With the help of robotic devices, modern technology has transformed agriculture and increased efficiency and output. As a result of research, autonomous robots are becoming more common, which helps to decrease human mistake and operator dependence [3]. Agriculture is being revolutionized by robots, which streamline labor-intensive chores like seeding, harvesting, picking, and disposing of waste while also increasing crop yields and decreasing repetitious tasks [4]. Due to their dependency on a computer server, mobile robots in agriculture handle issues with sustainability, food safety, crop losses, and productivity but come at high prices and are massive in size [5]. Agriculture is being revolutionized by robots, which make tasks more efficient, increase agricultural returns, and stimulate competitiveness. Advances in computer technology, forecasting, and automated processes have resulted from this transition [6]. Labor-intensive tasks in agriculture are being revolutionized by mobile robots, but the lack of a common technical vocabulary and defined planning criteria causes uncertainty among stakeholders and discourages advancement in this field [7].

2. Automation and Robotics in Agriculture

Since the 1950s, digital agriculture has witnessed an increase in the application of agricultural robots that employ sophisticated algorithms, sensor technologies, and control methodologies. However, because of their limitations in small-scale applications, their reliance on AI solutions prevents them from being widely adopted [8]. Smart farming incorporates cutting-edge technologies like Internet of Things (IoT), robots, and automation systems with current procedures as a way to address the manpower scarcity in agriculture. This increases productivity by reducing labor-intensive tasks. Nonetheless, cloud computing offers a scalable resource pool, addressing constraints such limited memory and processing power [9]. Mechanization and power-intensive production processes have substituted the labor-intensive nature of agriculture as an industry. Technological developments in robotics and AI over the past fifteen years have extended automation beyond standardized tasks by making it possible to inexpensively conduct non-standardized operations like crop sensing and fruit picking [10]. In order to ensure long-term sustainability, integrating robots into agriculture will require a multidisciplinary strategy. Robots are skilled at managing repetitive, difficult operations, especially those integrating AI [11]. Developments in agricultural robots address concerns such as labor shortages, urbanization, competition, population increase, and environmental preservation. Activities like clearing ground, planting, harvesting, estimating yield, and phenotyping are all done with them [12]. With its potential to solve both labor shortages and environmental sustainability, agricultural robotics is gaining popularity. For tasks like surveillance, application, collection, and conveyance, solitary robots are available; however, collaborative robot units are also on increasing popularity [13]. Modern agriculture incorporates agricultural robots for data-driven precision farming, accelerating plant breeding processes, and lowering the amount of manual labor inputs in an effort to enhance sustainable food, feed, fiber, and biofuel production [14]. With robotic harvesters, autonomous weed control, and machine vision increasing productivity and efficiency, automation serves an essential part in agricultural production [15]. An increasing number of agricultural duties, such as weed management, plant sowing, environmental assessment, and soil mapping, are being performed by robots. Technological developments like AI, Big Data, HCI, and Cloud Computing have improved its applications substantially [16]. The fourth revolution in agriculture, known as "Agriculture

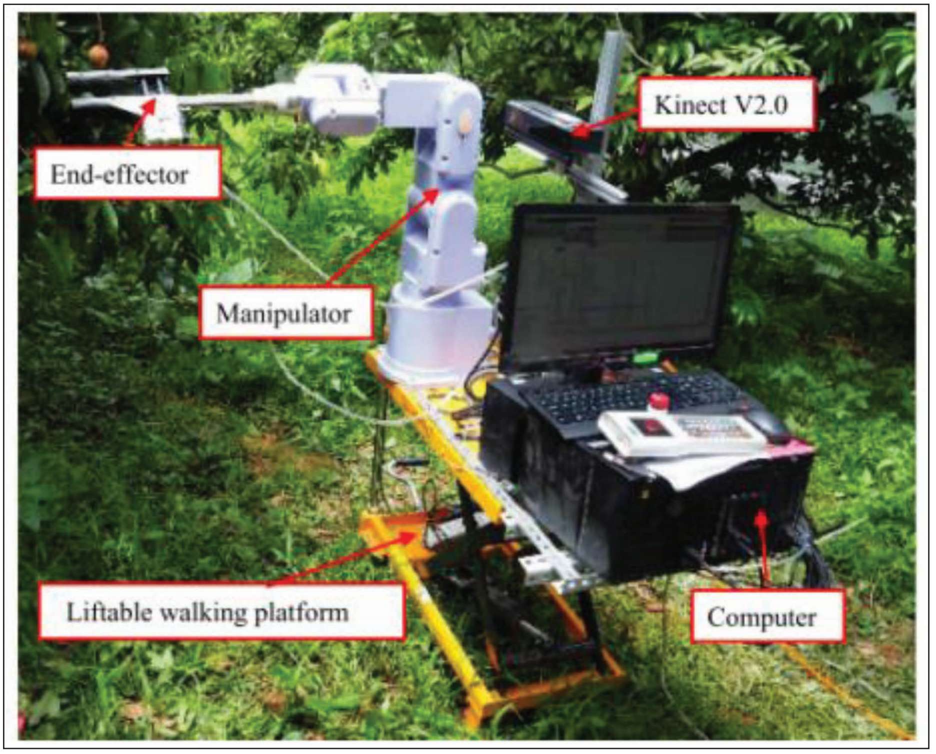

Figure 1. Autonomous fruits and vegetable robotic harvester

4.0," leverages digital technologies such as Big Data, AI, robotics, IoT, and Virtual Reality (VR) to improve farming techniques, daily operations, and sustainability [17]. An autonomous fruits and vegetable robotic harvester is shown in figure 1.

3. Recommendations

After thoroughly examining the past and present research on the robotics and automation techniques currently being employed by the agricultural sector, we propose following recommendations.

- According to the survey, drones are the preferred robotic choice for field monitoring. Perception solutions primarily employ vision and cloud point sensors, frequently combining machine learning for data analysis.
- In order to maintain global food production during workforce shortages as well as minimize ecological damage by eliminating human involvement, cooperative robotics in agriculture is essential.
- Human-robot interaction, agronomics, sensing technologies, and automation are some of the future topics in agricultural robotics research that this review aims to motivate researchers to explore.

- Agricultural robots strengthen regression models and deep learning networks, which depend on large training datasets, by enabling automated data collecting across plants and environments.
- A mobile robot that employs dynamic planning updates its plan on frequently in response to new information or an unforeseen event identified by the local obstacle avoidance system.

Conclusion

Agriculture 4.0 is a game-changing movement which incorporates AI, IoT, and cellphones to improve agriculture. It provides practical and affordable solutions to situations including resource shortage, climate change, and global population growth. Agricultural robots, or agro-bots, are an effective way to handle conventional agricultural procedures, which are mostly manual. Simplifying processes involves educating farmers about the advantages of employing autonomous robots. This study explores developments in mobile robot-assisted precision agriculture, emphasizing cutting-edge sensor and monitoring technologies and cutting-edge robotic solutions, with a particular focus on land-based robots. It discusses new developments in functionality and design. Filling the gap in the literature with a meticulous engineering approach, this work offers a theoretical framework for comprehending mobile robot planning in agriculture, concentrating on technological elements and planning considerations.

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