

Review

Actuators and Sensors for Application in Agricultural Robots: A Review

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Abstract: In recent years, with the rapid development of science and technology, agricultural robots have gradually begun to replace humans, to complete various agricultural operations, changing traditional agricultural production methods. Not only is the labor input reduced, but also the production efficiency can be improved, which invariably contributes to the development of smart agriculture. This paper reviews the core technologies used for agricultural robots in non-structural environments. In addition, we review the technological progress of drive systems, control strategies, end-effectors, robotic arms, environmental perception, and other related systems. This research shows that in a non-structured agricultural environment, using cameras and light detection and ranging (LiDAR), as well as ultrasonic and satellite navigation equipment, and by integrating sensing, transmission, control, and operation, different types of actuators can be innovatively designed and developed to drive the advance of agricultural robots, to meet the delicate and complex requirements of agricultural products as operational objects, such that better productivity and standardization of agriculture can be achieved. In summary, agricultural production is developing toward a data-driven, standardized, and unmanned approach, with smart agriculture supported by actuator-driven-based agricultural robots. This paper concludes with a summary of the main existing technologies and challenges in the development of actuators for applications in agricultural robots, and the outlook regarding the primary development directions of agricultural robots in the near future.

Keywords: agricultural robots; actuator; smart agriculture; environmental perception; end-effectors



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1. Introduction

In the last two decades, with the advent of the information age and unmanned farms, agricultural production methods have changed dramatically [1–3]. The development of science and technology has combined agricultural production technology with internet of things (IoT) technology more closely, making smart agriculture one of the mainstream modes of agricultural production [4–6]. In particular, the wide use of agricultural robots has revolutionized the traditional agricultural labor mode, reduced labor intensity, enhanced agricultural production efficiency, and improved agricultural products' production quality, promoting modern agriculture's development [7–9]. Agricultural robots are special robots applied in agricultural production operations and a new type of intelligent agricultural machinery, which can use multi-sensor fusion, automatic control, and other technologies to realize automatic and intelligent production of agricultural equipment, operating in the natural environment [10–12]. Nowadays, agricultural robots are being widely used in many aspects of agricultural production, completely or partially replacing or assisting people in agricultural production, improving agricultural production efficiency, and enhancing production safety performance [13–15]. According to the robot's working space, they can be divided into indoor and outdoor robots. On the one hand, indoor robots are mainly used in greenhouses and other similar scenarios, including indoor harvesting robots, fruit

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Table of Contents Sensors Actuators Research Development And Application

1. Understanding the eBook Sensors Actuators Research Development And Application
 - The Rise of Digital Reading Sensors Actuators Research Development And Application
 - Advantages of eBooks Over Traditional Books
2. Identifying Sensors Actuators Research Development And Application
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Sensors Actuators Research Development And Application
 - User-Friendly Interface
4. Exploring eBook Recommendations from Sensors Actuators Research Development And Application
 - Personalized Recommendations
 - Sensors Actuators Research Development And Application User Reviews and Ratings
 - Sensors Actuators Research Development And Application and Bestseller Lists

5. Accessing Sensors Actuators Research Development And Application Free and Paid eBooks
 - Sensors Actuators Research Development And Application Public Domain eBooks
 - Sensors Actuators Research Development And Application eBook Subscription Services
 - Sensors Actuators Research Development And Application Budget-Friendly Options
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 - ePub, PDF, MOBI, and More
 - Sensors Actuators Research Development And Application Compatibility with Devices
 - Sensors Actuators Research Development And Application Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Sensors Actuators Research Development And Application
 - Highlighting and Note-Taking Sensors Actuators Research Development And Application
 - Interactive Elements Sensors Actuators Research Development And Application
8. Staying Engaged with Sensors Actuators Research Development And Application
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Sensors Actuators Research Development And Application
9. Balancing eBooks and Physical Books Sensors Actuators Research Development And Application
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Sensors Actuators Research Development And Application
10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
11. Cultivating a Reading Routine Sensors Actuators Research Development And Application
 - Setting Reading Goals Sensors Actuators Research Development And Application
 - Carving Out Dedicated Reading Time
12. Sourcing Reliable Information of Sensors Actuators Research Development And Application
 - Fact-Checking eBook Content of Sensors Actuators Research Development And Application
 - Distinguishing Credible Sources
13. Promoting Lifelong Learning

- Utilizing eBooks for Skill Development
- Exploring Educational eBooks

14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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