

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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