Development of Agricultural Robots in Japan

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Abstract: The development process and direction of agricultural robots in Japan are introduced in this paper. Through the summary of the latest research results of agricultural robots in field production and facility production in Japan, it is shown that agricultural robots have great potential as a new generation of intelligent agricultural machinery. Driven by the demand caused by technology accumulation and labor shortage, Japanese agricultural robots have developed rapidly, which is worthy of reference and learning.

Keywords: Japanese robot; agricultural robots; plant factory

1. Introduction

With the increasing industrialization, scale and precision of agricultural production, agricultural robots show great significance [1]. The so-called agricultural robot is an automatic intelligent agricultural equipment with autonomous movement, information perception and re-programmable functions for the purpose of completing agricultural production tasks. Agricultural robots have been applied in seedling raising, seedling transplanting, grafting and agricultural product harvesting. Intelligent agricultural machinery and equipment points out a way to improve agricultural production efficiency, which can completely or partially replace or assist people to complete specific and complex production tasks efficiently, conveniently, safely and reliably.

Agricultural robots have strong seasonality, complex and changeable working environment and complex working objects. Flexible processing is required when the execution end contacts with the working object. Therefore, the requirements for robot control and sensing system are in need [2]. According to the use scenarios of agricultural robots, they can be divided into field production agricultural robots, facility production agricultural robots, agricultural product processing robots, etc. Among them, field production agricultural robots and facility production agricultural robots are the mainstream of agricultural robots.

Agricultural robots for field production include sowing robots, harvesting robots, plant protection robots, transplanting robots, etc. (Figures 1-6). Picking operation is one of the most time-consuming and laborious production links. Ensuring timely fruit harvesting, reducing harvest operation intensity and labor cost are important driving forces for the development of fruit and vegetable picking robots.

Facility production agricultural robots include grafting robots, vegetable harvesting robots, plant factory seedling transplanting robots, etc. Because the grafting propagation technology is relatively mature and the artificial grafting efficiency is low, promoting the application of grafting robot can achieve considerable economic and ecological environment.

Based on the above reasons, foreign agricultural robot technology has developed rapidly in recent 40 years, while Japan's agricultural robot technology is in the forefront of the world [3].

Figure 1. A Kiwi picking robot developed by Waikato University of New Zealand

Figure 2. A vegetable planting robot developed by FarmWise company of USA

Figure 3. An automatic harvesting robot developed by AGRIST company of Japan

Figure 4. A strawberry picking robot launched by Spanish start-up Agrobo

Figure 5. A lettuce picking robot launched by American start-up Blue River Technologies

Figure 6. Ecorobotix farm weeding robot of Switzerland

2. Japanese Agricultural Robots

Due to the reduction of labor force and other problems in Japan's agriculture, in order to make up for the shortage of labor force, Japan has vigorously developed agricultural robots since the 1980s, which were first applied to fruit and vegetable picking [4]. In 1995, Okayama University in Japan designed and developed a grape harvesting robot (Figure 7) for orchard Trellis Cultivation Mode [5], which is composed of manipulation mechanism, visual sensor, data transmission device and end execution device. By changing the end effector, berry collection, spraying and bagging can be completed. In 2009, Utsunomiya University developed a strawberry picking robot that can work under different lighting conditions. The red fruit is recognized by image recognition method and the position of the fruit is accurately located. In 2015, Panasonic developed a greenhouse tomato picking robot (Figure 8), which uses cameras and distance image sensors to detect the distribution of plants and fruits in the area to be harvested, evaluates the harvest feasibility of the target object according to the obtained tomato color, and forms the actual picking path and attitude planning by obtaining the shape, position and other information of stems, leaves and tomatoes in the area. The robot continuously improved the power and system stability, and can work continuously for 5 hours. By 2020, the accuracy rate of harvest feasibility increased to more than 85%.

Figure 7. A grape harvesting robot designed by Okayama University in Japan

Figure 8. A tomato picking robot developed by Panasonic in Japan

In terms of multi-functional agricultural field production of agricultural robots, the Japan Comprehensive Research Institute formed an alliance with Keio University and other units in 2019 to develop four-wheel agricultural robot Dongkey [6] (Figure 9), which has the basic functions of independent operation, automatic tracking, monitoring pests, environmental awareness, communication and so on. As long as additional kits are added, they can even cope with handling, operation management, weeding and other functions.

Figure 9. Dongkey, a multi-functional agricultural robot in Japan

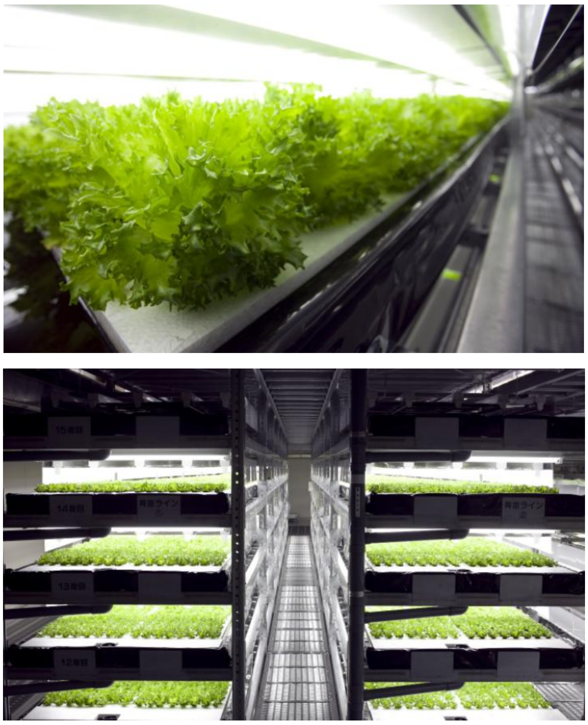

Figure 10. The agricultural robot working in Spread Plant Factory of Japan

In terms of the application of agricultural robots for facility production, the Japanese company Spread is building the world’s first robot farm (Figure 10) [7]. The farm is located in kuoka City, Kyoto Prefecture. By using facilities to produce agricultural robots, the number of daily output of lettuce will be increased from 21000 to 50000. The conveyor belt equipped with manipulator can accurately transplant lettuce seedlings without damaging them. Automation systems in indoor farms can also control temperature, humidity and carbon dioxide concentration, and even disinfect water and control light sources.

3. Conclusion

The intensive and large-scale process of global agricultural production is accelerating, and the demand for agricultural robots in various countries will continue to increase (Figure 11). Due to the complexity, variability and non-structure of agricultural working environment and objects, the research and development of agricultural robots is not easy. It is necessary to invest in cutting-edge directions such as working object recognition and positioning, navigation and path planning, sorting and monitoring of working objects, so as to promote the research and development of intelligent agricultural robots with multi environmental adaptability.

Technically, with the deep integration of new generation information technology such as cloud computing, big data and artificial intelligence with agricultural technology, agricultural robot as a new generation of intelligent agricultural machinery, will break through the bottleneck and be widely used. Deep learning improves the perception and decision-making ability of agricultural robots, such as phenotypic feature recognition, scene recognition and positioning, and crop disease recognition. Due to the strong foundation of Japanese robot technology and the eager demand brought by labor shortage, Japanese agricultural robots have developed rapidly, which is worthy of our notice.

Figure 11. Rapid development of robot agriculture in Japan

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