# Research Progress and Application Issues of Harvesting Robots - An Example from the Jasmine Industry

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**Abstract:** With the rapid development of picking robot technology and the deepening of research at home and abroad, the types of picking robots have begun to diversify, and the popularity and trend of floral teas, jasmine tea has gradually appeared. The difficulty of picking jasmine flowers in the harsh growing environment and how to reduce the cost of adjusting the picking rate has been a hot issue of concern. This paper summarizes the current research status of picking robots at home and abroad, introduces the research results of several typical picking robots, and points out the possible problems of using relevant picking robots for jasmine picking: few target functions, not easy to detect, and large size. The design of a low-carbon, medium-sized, target-functional, and low-cost jasmine picking robot is proposed to solve the related application problems. An effective reference path is provided for the development of robots in the picking industry.

## 1. Introduction

Picking robots are at the forefront of intelligent research in agricultural technology. However, even in developed countries where robots have reached a high level of intelligence, there is still a high reliance on humans to perform most aspects of picking technology. Without the help and replacement of picking robots, agricultural products are much less competitive in the marketplace. The need for robots to replace manual labor in the harvesting industry has become a critical need in the development of domestic and international facilities. Jasmine, an upright or climbing shrub, has been a favorite of royalty, scholars and diplomatic envoys throughout ancient and modern history for jasmine tea. However, due to vicious competition and narrow channels, jasmine tea declined and left the public eye. In order to balance the development of China as a whole, Xi Jinping proposed a strategy of rural revitalization in his report to the 19th National People's Congress of the Communist Party of China on October 18, 2017, asking cities to help reform the countryside and get rid of poverty. As the popularity of jasmine tea and the demand for it surges, the problems of inefficient picking and high labor costs for jasmine tea are expanding. Picking jasmine is one of the most time-consuming and painful parts of the production chain. Although international research on picking robots is currently proliferating, their agricultural facilities are mainly focused on labor-intensive industries. This has led to an unprecedented lack of research on jasmine picking robots and the level of automation in jasmine picking remains low. The purpose of this paper is to explain typical cases of picking robots at home and abroad, and then to summarize and analyze the problems that have arisen from the use of picking robots in the jasmine picking industry, to propose relevant solutions, and to look ahead to the future development trends of this industry.

## 2. Development of picking robots abroad

Compared with the exploration and development of picking robots in China, foreign countries already have relatively mature technology. In the 1970s, Japan began the research on agricultural robots and developed many agricultural robots, one of which is an agricultural picking robot. At the beginning of the 1990s, the research on "precision agriculture" technology began to deepen in the developed countries, and many researchers believe that robot technology will become an important pioneer technology for the sustainable development of agriculture in the 21st century. In the early 1990s, research on "precision agriculture" technology began to deepen in developed countries, and many researchers believe that robotics will become an important pioneer technology for the sustainable development of agriculture in the 21st century. [1]Picking robots, as an important picking system for agricultural vegetables, flowers and fruits, have also received extensive attention and development.

Currently the main research directions of picking robots are categorized into (1) human-robot interaction and mutual assistance (2) intelligent self-service.[2]

### 2.1 Human-robot cooperative harvesting robot

According to American scholar Saridis, intelligent control systems can be divided into three levels. They are organization level, coordination level and control execution level. The main task of the organization and coordination level is to perform some reasoning and planning tasks with low control precision, so the tasks of finding and locating the picking robot and navigating the picking robot are classified into these two levels, which are carried out by manual operators. The control execution level can directly control the hardware systems of the robot, such as sensor modules, drive modules, therefore, the control level systems such as joint control system and motion trajectory planning of the picking robot are planned at the control execution level and executed by the robot control system.[2]

The effective combination of man-machine cooperative material selection robot effectively reduces the card probability and recklessness rate of AI encountering unexpected events on a reasonable basis, and improves the efficiency of agricultural engineering selection.

#### 2.1.1 Human-assisted orange picking robots

Based on the concept of human-robot cooperative picking robots, the Spanish Institute of Automation developed the Orange Picking Robot Agricultural Robot, in which, after determining the position of the fruit, the operator aims the laser beam of a laser rangefinder at the fruit. When the emitted laser beam encounters the surface of the fruit, a part of it folds back into the laser rangefinder and the relative distance between the fruit arrangement and the rangefinder is measured. Combined with the determined angle value, the fruit can be accurately located and its position placed in the dynamic data area.

The control system obtains coordinate data from the dynamic data area and compares it with the current position of the robot's end-effector to select the best path.

### 2.2 Autonomous Intelligent Picking Robot

Agricultural researchers are focusing on developing machine vision systems and artificial intelligence to achieve the goal of completely replacing human picking operations by agricultural robots.

#### 2.2.1 Tomato picking robots

Kondo-N et al. in Japan developed a tomato picking robot that uses a color camera as a sensor to identify and locate ripe fruits based on their growth position, and a binocular vision method to localize the fruits, and then avoids picking obstacles using a 7-degree-of-freedom SCORBT-ER industrial robot arm.

Kondo then designed a robotic arm that utilizes a wheeled chassis and seven degrees of freedom to effectively solve problems such as obstacles encountered when picking tomatoes. In addition, a flexible four-finger end-effector was developed, which, in combination with a vacuum suction system, frees up space for picking neighboring fruits and reduces picking delays due to obstacles in the way.

#### 2.2.2 Cucumber picking robots

Kondo-N et al. in Japan have developed a cucumber picking robot . To make it easier to observe and pick cucumbers, the team added a filter to the camera to recognize cucumbers based on their reflectance spectral properties. Its end-effector is equipped with a cutting knife and mechanical fingers to recognize melons and then perform stem cutting.

## 3. Examples of the current status of domestic harvesting robots

Zhang Tiezhong of China Agricultural University led a team from the strawberry picking industry in an in-depth study of strawberry picking robots, developing a strawberry starting and lifting model with multiple effects. The team designed a small picking robot with a miniature tracked chassis, a right-angle coordinated robotic arm and an integrated end-effector for clamping and shearing. The end-effector has a fiber-optic sensor in its jaws and a small camera at the bottom to detect distance and angular deviation of the fruit. The picking robot microtrack is designed to allow the robot to traverse narrow overhead areas without being obstructed by objects. The prototype, named "Picking Boy 1", was primarily used for picking individual strawberries, with an average time to pick a single fruit of 18.54 seconds and a success rate of 88%. [8: "Greenhouse"].

Subsequently, Qingqing Feng and others at the National Engineering Research Center for Intelligent Mobile Devices developed an intelligent mobile picking robot that uses suction cups for continuous traction, an articulated industrial robotic arm, an end-effector to burn off the fruit stalks via wires, and a mobile wheel device to navigate using sonar. This development addressed the low picking efficiency of the prototype Picking Boy 1, which could pick 100 strawberries at a time. A total of 121 trials were conducted and the average picking time per strawberry was only 0.26s-0.313s.[4]

## 4. Problems with the use of picking robots in jasmine harvesting

### 4.1 Lack of popularization of robotics

Although picking robots are one of the key developments for sustainable agricultural facilities and equipment in the 21st century, current domestic and international research on picking robots is still focused on the most common fruits and vegetables. Zhao et al. Shanghai Jiao Tong University developed a belt-driven roller blade end-effector and suction cup cylinder end-effector for deep tomato picking, using binocular stereo vision to locate the fruit; the Korean Academy of Agricultural Sciences, in order to reduce the robot's footprint, used a strawberry picking robot with a flexible shaft-driven end-clamp shear head and rear motors that used a laser to detect the distance to the fruit stems tracking, once again breaking strawberry collection records with an average of Labor-intensive fruit and vegetable chain establishment and research, flower and tea picking industries that are growing in popularity are almost constant. Uneven development in the study area has led to a lack of robotics in the jasmine picking industry.

### 4.2 Non-targeted model

As you can see above, intelligent research picking robots have evolved rapidly in recent decades, potentially because research teams have been "peer-to-peer" correcting problems related to the needs of the field and solving technical problems on a one-to-one basis. Spain's human-robot collaborative orange picking robot utilizes human-robot collaborative technology to reduce the time it takes to pick oranges by hand. Kondo-n, Japan, developed an initial tomato picking robot designed with a color camera that uses a 7-degree-of-freedom industrial robot arm to differentiate between ripening and obstacles, improving the robot's intelligence and dexterity. To make tomato picking less difficult, Kondo-n then designed a flexible four-finger end-effector incorporating a vacuum suction system for isolated fruit picking. With the groundbreaking innovation of the prototype, top-notch technology was then put in place, but even the best of the best could not be put together for general use due to the lack of proven equipment in the jasmine picking industry.

### 4.3 High picking costs

Jasmine loves hot weather and plenty of light and blooms from July through September. In order to obtain large quantities of fragrant jasmine, pickers must work for 10 hours in the heat, bowing among the flowers. The intensive picking over a long period of time leads to whiplash. Add to this the rainy season, when the weather changes too much for farmers to avoid rain, and when the picked flowers get wet they rot. The high cost of labor in the mountains led to low labor processing costs, which seriously affected the jasmine market. As demand expands, a small number of jasmine picking robots have begun to appear on the market. However, the existing picking robot picking technology is limited, the shear mechanism of the picking robot is directly mounted on the robot arm, and the picking robot relies on the gravity of the picked jasmine flowers to fall into the collection box below, so the flowers are thin, soft, and easy to break, which reduces the quality of jasmine flowers. This, coupled with the fact that the jasmine flowers are always in a constant falling position, puts tremendous pressure on the bottom, reducing the quality of the jasmine flowers and leading to more picking defects and higher costs.

## 5. Jasmine picking robot design

### 5.1 Overall structure

A jasmine picking robot is a new type of jasmine picking robot, including a frame body, a multi-degree-of-freedom picking arm, a shearing cylinder, a shearing mechanism, a clamping cavity, an exhaust pipe and a sliding device. The front end of the frame body is provided with a multi-degree-of-freedom picking arm, the driving end of the multi-degree-of-freedom picking arm is slidingly provided with a shearing barrel. The hollow of the shearing barrel is provided with a shearing mechanism, the interior of the shearing barrel is provided with a holding cavity, and the bottom of said shearing barrel is connected with a feeding tube. It said that feeding tube is connected with the holding cavity, a collection box is provided at the top of said frame body, and a transverse sliding plate is provided at the top of said collection box, said transverse sliding plate is moved along the lengthwise direction of the collection box. The transverse slide plate is provided with a longitudinal slide rail, and the longitudinal slide rail is provided with a longitudinal slider that moves along the width direction of the collection box. When a jasmine collection robot collects jasmine material, the jasmine collection robot utilizes a highly flexible free picking arm to record a shearing device on the picking arm, avoids selecting leaves through a camera device on the picking arm, and then recognizes the selection of jasmine through an existing jasmine pattern algorithm, and then collects jasmine into the collection box through a downwardly directed conduit and a left- and rightwardly moving lateral longitudinal sliding plate.

### 5.2 Cushioning and pressure-resistant design

When the picking robot moves to pick jasmine flowers, the picking robot collects jasmine flowers at a rate of 50 flowers at a time within 10 seconds by means of the shear mechanism of the high degree of freedom picking arm. The collection box has a cushioning effect on the jasmine flowers to prevent them from piling up in the box and causing crushing injuries at the bottom.

### 5.3 Specific implementation strategies

When jasmine pickers need to pick jasmine flowers in mountainous areas, the robot utilizes a tracked walking mechanism to gently pick jasmine flowers in potholes. In order to improve the picking efficiency, the robot drives the multi-degree-of-freedom robotic arm to the front of the jasmine flowers, locates the jasmine flowers through the multi-point positioning camera on the robotic arm, puts the shear cylinder into the jasmine flowers, closes the blooming jasmine flowers in the holding cavity, and then cuts the jasmine branches through the shearing mechanism. The shearing mechanism consists of a shearing knife, an articulated shaft, a stranding motor, a lifting wire, a wire away from the connecting wire, a stranding disk and a photoelectric sensor. When the jasmine flower is completely wrapped in the clamping cavity, the photoelectric sensor reacts and the chain motor starts to rotate while the pulling wire is wrapped around the chain disk 2. The pull wire begins to move, pulling the connecting wire and pulling the shear knife onto the shaft of the articulating shaft, thereby shearing the jasmine in close proximity to the jasmine flowers. The cut jasmine flowers fall into the drop tube.

In order to prevent the jasmine flowers from unfortunately falling off during the picking process, causing unnecessary losses, the robot, while directly placing the jasmine flowers into the low-feed tube, cuts the jasmine flowers through a shearing mechanism to cushion the fall of the jasmine flowers, avoiding the jasmine flowers from directly falling into the collection box, reducing the injury to the jasmine flowers, and improving the quality of the picked jasmine flowers. In order to prevent the falling jasmine flowers from being squeezed and injured in the collection box, the transverse slide plate is in the form of a C-shape, and the opening thereof is slidingly connected with a first silk rod and a light rod. The jasmine collection box is equipped with a first filament motor, the output shaft of which is connected to a transmission device at one end of the first filament rod. The motor drives the filament to rotate, and the light rod is used to limit the high degree of freedom angle of rotation of the transverse slide plate so that the transverse slide plate moves only along the filament axis. The longitudinal slide plate has a "t" shape. The slide plate has a second filament helix at the bottom and a second filament motor at the other end. The filament motor is connected to the filament helix, and the motor rotates the filament helix, limiting the high rotational freedom of the longitudinal slide plate so that the longitudinal slide plate only moves along the axis of the second filament helix. The transverse slide plate and the longitudinal slide plate drive the downcomer tube to move within the length and width of the collection box so that the jasmine flowers are uniformly collected in the collection box.

## 6. Conclusion

Agricultural robotics is now an emerging field of robotics, and picking robots are gaining attention and research, as well as constant updates with strong development capabilities. In an industry where jasmine picking is gaining attention, the demand for jasmine picking robots is increasing due to bottlenecks in picking technology. Combining the existing picking robot technology with the expanded technology of jasmine picking is beneficial to the later development of jasmine picking robots and has practical application value. It is believed that in the near future, jasmine picking robots will gradually be used in major jasmine picking bases.

## References

[1] Zhao, Yun, Wu, Chuyu, Hu, Xudong, and Yu, Gaohong. Research progress and problems of agricultural robots. Journal of Agricultural Engineering, 2003(01): 20-24.

[2] Fang JJ. Status and progress of mobile harvesting robots. Journal of Agricultural Engineering, 2004(02): 273-278.

[3] Ceres R., Pons J. L., Jimenez A. R., et al. A robot used to assist in fruit harvesting. Indus Experimental Robotics, 1998, 25(5): 337-346.

[4] Baoxing Gu, Changying Ji, Haiqing Wang, Guangzhao Tian, Gaoyang Zhang, Ling Wang, et al. Design and experiment of intelligent mobile fruit picking robot. Journal of Agricultural Machinery, 2012, 43(06):153-160.