



# Design and Implementation of Walking Control System for Orchard Plant Protection Robot Based on Artificial Intelligence Algorithm

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**Abstract.** In order to improve the stability of fruit recognition of orchard plant protection robot, the walking control system of orchard plant protection robot was established based on artificial intelligence algorithm. Orchard eppo robot control system design of hardware platform is a rate by machine controller, signal controller, chassis motor drives, cameras and proximity switch of these five parts, is mainly responsible for transferring information to the control system, do matting for software design, on this basis, the set can intelligent power saving communication program and the sensor data acquisition, the recognition data transmission to the robot control system, the implementation is based on artificial intelligence algorithm orchard plant protection design of the control system of walking robot. By combining software and hardware, the research on the walking control system of orchard plant protection robot based on artificial intelligence algorithm is completed. From the results of software and hardware experiments, it can be seen that compared with the traditional robot walking control system, the application of this system for fruit recognition has higher stability and can effectively reduce the workload.

**Keywords:** Orchard plant protection robot · Walking control system · Sensor data acquisition program · Fruit identification

## 1 Introduction

At present, intelligent science and nonlinear science have been widely used in various fields. Then some new optimization methods which are different from traditional optimization methods are developed rapidly, namely intelligent optimization algorithm, such as artificial neural network, particle swarm optimization, genetic algorithm, support vector machine, etc. Among them, wavelet neural network and support vector regression machine have the advantages of fast computing speed, strong fitting ability and high precision, and they are widely used methods to solve nonlinear problems with very broad application prospects. Wavelet neural network is a new kind of neural network based on wavelet theory and neural network theory. Support vector machine (SVM) is a new machine learning method proposed by Vapnik and his scientific

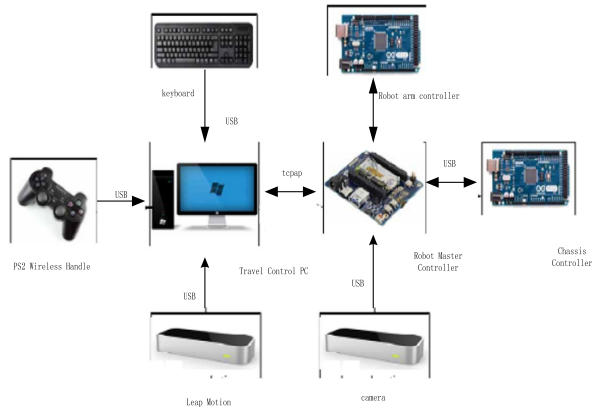
research team at the end of the 20th century when studying statistical learning [1]. This method can be used to solve practical problems such as small samples, non-linearity and high dimensionality, avoid local minimum points and have high generalization ability. This algorithm is used to solve regression problems and developed into support vector regression machine. The generation of support vector regression machine is of great significance for regression approximation.

It is generally believed that the orchard plant protection robot is a kind of automatic mechanical harvesting system with perceptive ability, which can be programmed to complete the picking, transporting, packing and other related tasks of fruits. Picking robot requires knowledge of mechanical structure, visual image processing, robot walking dynamics, sensor technology, control technology and computational information processing. Orchard plant protection robot can automatically detect the fruit and save the data. When it needs to know the data of a certain aspect of the fruit, it only needs to use the control software to read the required data and carry out certain statistical analysis and chart analysis. The data measured by the lab-type fruit phenotype detection robot system is generally more accurate, but its statistical ability is limited. When too many fruits need to be tested, the lab-type fruit phenotype detection robot system should not be used. Compared with laboratory fruit rapid phenotype detection robot system, the detection speed of greenhouse fruit rapid phenotype detection robot system has been greatly improved, but the cost of greenhouse fruit rapid phenotype detection robot system is generally higher. In order to solve the problem of fruit phenotype detection in fruit breeding, aiming at the problem of rapid detection of fruit phenotype parameters, a walking control system of orchard plant protection robot was established based on artificial intelligence algorithm to improve the reliability and work efficiency of breeding decision.

## **2 Hardware Design of Orchard Plant Protection Robot Walking Control System Platform**

The platform hardware of orchard plant protection robot walking control system mainly includes remote control PC, robot master controller, mechanical arm controller, chassis controller, proximity switch, camera, keyboard, Leap Motion gesture controller, PS2 wireless controller, motor driver, power module and so on.

As shown in Fig. 1, the hardware of orchard plant protection robot control system platform. In order to ensure the reliable performance of orchard plant protection robot control system platform, the choice of robot master controller is particularly important.



**Fig. 1.** Hardware structure of orchard plant protection robot control system platform

## 2.1 Robot Master Controller

The main controller of the robot should be able to send control information to the chassis controller to realize the operation of the chassis, to process the image information collected by the camera, to be able to move, to send control information to the manipulator controller to realize the walking of the manipulator, and to communicate with the remote control PC [2]. This paper selected the Intel Joule platform, which has a wide range of applications in the fields of meter vision, robotics, unmanned aerial vehicles and other highly demanding fields. The platform is based on the module computing system, which can achieve 4K resolution video shooting and display, and support the application of depth camera. The platform is equipped with a 64-bit 1.7 GHz quad-core intel. atomtm processor T5700, equipped with 4 GB LPDDR4 RAM and 16 GB eMMC memory, and provides a wide range of physical interfaces, including USB 3.0, multiple GPIO, I2C and DART interfaces, as well as wi-fi and Bluetooth 4.1. In addition, it supports the application of intel. Real sense depth of field sensing camera technology, suitable for computer vision systems with high requirements.

## 2.2 Gesture Controller

Leap Motion is a new type of intelligent interactive hardware released by Leap, a motion-sensing controller manufacturer. It mainly captures the walking of hands. It tracks and locates hands, fingers and similar tools based on infrared imaging and triangulation ranging principles, and provides these collected real-time information to developers for human-computer interaction. Leap Motion can grasp and wave at will in an effective space to conduct smooth operation of PC space separation, and it can accurately track the movements of hands and fingers no matter how small they are, with an accuracy of 0.01 mm. Leap Motion has two infrared cameras and three LED lights used to illuminate the target. The data is collected in frames, and the maximum frame rate can reach 200 frames/second. It can recognize the continuously changing Motion,

track multiple targets at the same time, detect the walking information of the target, and capture the picture from different angles [3]. Leap Motion provides rich API interfaces for different languages, making secondary development more convenient. Leap Motion USES the cartesian right-handed coordinate system. The axis is parallel to the sensor and points to the right of the screen. The axis is perpendicular to the sensor and points to the upper part of the space.

Leap Motion connects to the PC's USB port via a USB cable and recognizes a space of an inverted quadrangle of about 60 cm. In the process of use, Leap Motion regularly sends the walking information of the hand to the PC. Each information is called a frame, and each frame contains a list of all objects and corresponding information, including palm, finger and tools [4]. For each object captured, Leap Motion will assign a unique identity. Once the object enters the visual space and obtains an identity, the identity will remain unchanged as long as the object does not disappear in the visual space. According to the unique mark allocated by Leap Motion for the object, and then according to the axial vector, Angle, translation vector, scale factor and other data generated by the current frame and the data of the previous frame, the information of each walking object can be inquired, and the basic information of hand walking can be obtained.

### 2.3 Chassis Motor Driver

Arduino is an open source electronic design platform that is fast, flexible and easy to use. The software, namely the hardware schematic diagram of the program development environment ArduinoIDE oArduino in the computer, the IDE software and the core library files are open source, allowing the original design and corresponding codes to be arbitrarily modified within the scope of the open source protocol [5]. The characteristic of Arduino IDE is that it can be used on Windows, Mac and Linux. After simple learning, it can be developed quickly. Based on ATmega2560, the Arduino Mega 2560 adopts USB interface as the core circuit board. It has 54 digital IO ports, 16 analog IO ports, 4 DART ports and one USB port, which is suitable for application scenarios requiring a large number of IO interfaces. It can choose three power supply methods: power supply through the power socket; Power supply through GND and VIN pins; USB interface power supply, this paper adopts the direct power supply method of USB interface [6].

### 2.4 The Camera

The camera in this paper USES Realsense r200 produced by Intel company, and its target USES mainly include: 3d capture of face, human body and environment, depth enhancement reality, depth enhancement photography and video, measurement, face detection and tracking, etc. Specifications: distance; Depth of field/infrared: 60 frames per second, resolution: RGB: 30 frames per second, 1080; Appearance size:; For start. It should be noted that only the basic function of image acquisition is used in this paper, but considering the needs of follow-up research and application, such a depth camera is specifically selected here [7].

## 2.5 Proximity Switch

Orchard eppo robot installed a camera and a proximity switch, camera installed at the rear of the car can ensure the PC to be able to see the scene of the homework, in the robot walking forward, can control the robot will not hit the obstacles ahead, from the image and the right and left sides of the car body is the blind area is likely to hit obstacles, in order to prevent the happening of this kind of situation, this article USES proximity switch to realize the obstacle avoidance.

Proximity switch is a position switch that can be operated without direct contact. When the object enters the inductive surface of the proximity switch, the switch can be activated without direct contact and any pressure applied, thus providing control instructions for devices such as computers. Picking robot using two proximity switch, and respectively installed on the both side of the chassis, when on the left side of the barrier into proximity switch movement distance, the left side of the proximity switch to chassis controller switch quantity information, chassis controller receives the information, by controlling the motor realize the obstacle avoidance, the principle of implementation on the right side with the left side is the same. At this point, the hardware design of orchard plant protection robot walking control system was completed [8].

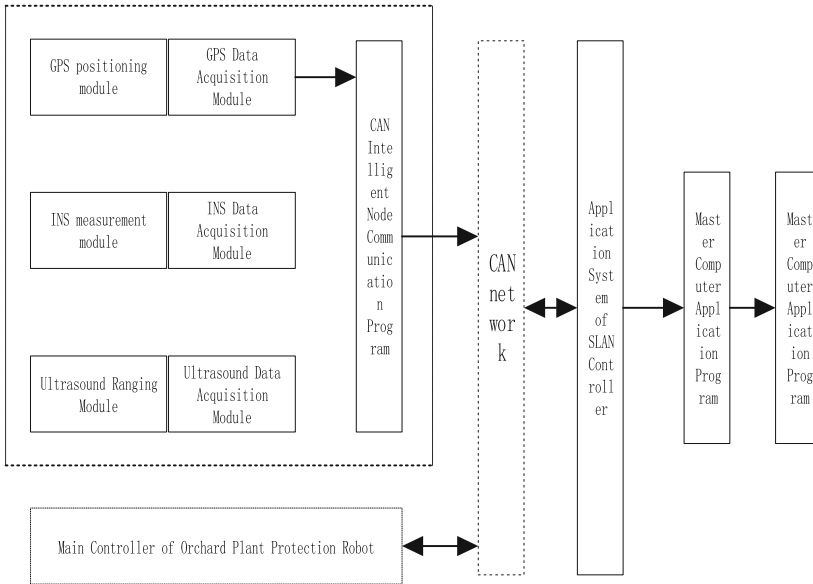
## 3 Software Design of Orchard Plant Protection Robot Walking Subsystem

For the orchard plant protection robot system, the control system software is the core. This chapter mainly carries on the design to the orchard plant protection robot walking control software, including the intelligent control program, the sensor data acquisition program, each application program and so on.

### 3.1 Can Intelligent Power Saving Communication Program

The following design is made for the walking control system of orchard plant protection robot: firstly, the can intelligent node communication driver is designed; Secondly, GPS positioning module, INS measurement module and ultrasonic ranging module are designed, which are used to collect data. Thirdly, the main controller, robot controller and related applications of android phones are designed [9]. See Fig. 2 for system composition.

As can be seen from Fig. 2, the main function of can intelligent node communication program is to receive sensor data through relevant interfaces and transmit the data to robot control machine through can wireless network. Therefore, this program mainly transmits some data collected by the sensor to the robot control machine. In the design of can intelligent node communication program of orchard plant protection robot walking control system, it mainly designs can communication program and serial communication program.



**Fig. 2.** Software design of robot walking subsystem

### 3.2 Sensor Data Acquisition Program

Relevant sensors used in this design include sensors of GPS positioning module, sensors of NS measurement module and sensors of ultrasonic ranging module [10]. These sensors can give orchard eppo robot control system provides functions such as coordinate information, including the location information of robot body, the activities of the robot body information, job information of robot body, etc., and the speed of the robot body information, whether there is any obstacle, with obstacle distance how far is it and other related information. In this section, the relevant sensor data acquisition program is designed.

The GPS positioning module used in this research USES the GPS product of ay-gps268 produced by suzhou aiyu technology co., LTD. This receiver has high precision and can realize dynamic reception. After being connected to the chip of can smart node, relevant instruction data can be exchanged. This GPS positioning module follows a certain codestream format and forms a data protocol. According to this protocol, the data format can be analyzed first, and then the data can be collected and processed [11, 12].

Data format analysis: the relevant GPS positioning module adopted in this study can output different information according to the requirements of the system, but the GPS positioning function needs to be simplified. Therefore, the data format should be analyzed to determine the data type and whether the data contains positioning information. Finally, the GPS positioning module will send these information to the serial port, and finally the serial port will receive the information, and then carry out the next step of processing.

According to the relevant code stream protocol, it can be known that the data sent by the GPS positioning module to can smart node is composed of four parts. The first part is the frame header, which is represented by \$GPRMC. Second, data valid area; Three is the position inspection; Four is the end of the frame. For the transmission of the data itself, it is need to use a serial port on the can intelligent node, but need to speed up the speed and process, in order to improve the efficiency of data transmission, so the GPS module design, data collection procedures not first to receive all the information, and according to the format of the data itself characteristic, carries on the corresponding data acquisition program design, makes the individual received data more accurate, the process is shown in Fig. 3.

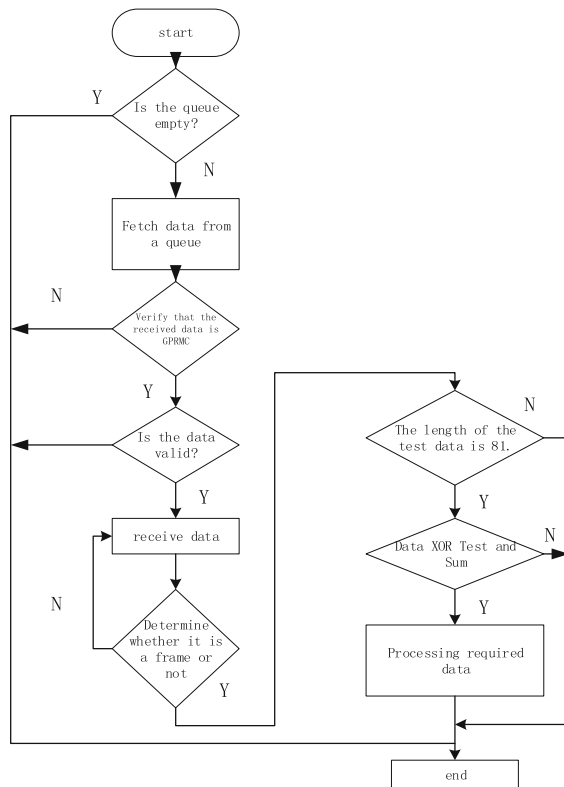


Fig. 3. Flow chart

As can be seen from Fig. 3, in the GPS data frame acquisition program, the first step is to judge the data sent from the serial port. If it is determined that no data is sent, exit the program. If it is confirmed that there is data sent, and the data frame header detected is \$GPRMC, it can start the cyclic receiving of characters [13, 14]. Because in the valid area of the data, there is the positioning status identifier of the data, so the validity of the data is judged according to the identifier. If the data is judged to be

invalid, the process will suspend the data receiving, and then wait for the new data frame, and send the data again after artificial intelligence calculation. The ideal value is obtained according to the principle of artificial intelligence algorithm, and is defined as formula (1).

$$E = \frac{1}{2} \sum_{s=1}^S (y_s - d_s) \tag{1}$$

In formula (1),  $E$  is the learning sample,  $y$  is the input vector component ordinal number,  $d$  is the output vector component ordinal number,  $s$  is the learning sample ordinal number.

A linear regression model introducing activation functions:

$$y(t) = \sum_{i=1}^n q_i(t)p_i + \omega(t)k \tag{2}$$

In the formula:  $n$  is the number of multi-peak walking nodes in the memory file of the control system;  $y(t)$  is the expected output value;  $q_i(t)$  is the calculated regression factor in the walking section of the system;  $p_i$  is the connection weight between the walking nodes;  $\omega(t)$  is the calculated residual. According to the model combined with the change parameter  $k$ , the walking center node is obtained:

The basic framework of artificial intelligence algorithm is derived from formula (1), which is defined as formula (2).

$$\begin{cases} W_{KI} = \frac{W_{KI} + \alpha W_{KI}}{y(t)} \dots\dots\dots i = 1, 2, \dots, n \\ v_k = \frac{v_k + \beta v_k}{y(t)} \dots\dots\dots k = 1, 2, \dots, l \end{cases} \tag{3}$$

In formula (2),  $\alpha$  and  $\beta$  are the learning rate respectively;  $W_{KI}$  represents the new network parameter, and the mathematical relationship between its input and output can be expressed as formula (4).

$$v_k = \frac{\partial E}{\partial v_k} = (y - d) \tag{4}$$

Formula (4)  $\partial E$  said in one of the first order  $\partial v_k$  said assume approximate fitting to get the output of the function and to determine if the final data is valid, you can to continue to receive data, and then to judge the data frame tail, and then if received the character frame is not the end, the need to continue to receive data, and then put into the data buffer. Because for GPS receiver, the received information is not necessarily complete, mainly based on the number of bytes. If the number of bytes is lower than the number of bytes standard, the data is incomplete and can not be processed. This is where the checksum comes in. At this point, the orchard plant protection robot walking control system software design part.

## 4 Experimental Analysis

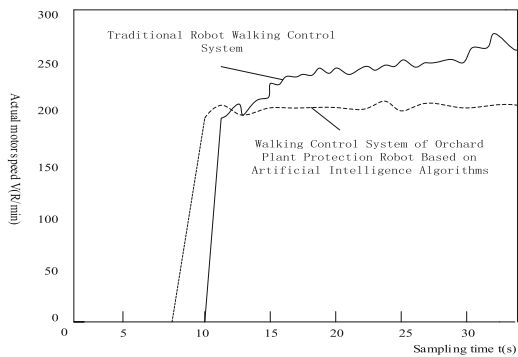
After the completion of software and hardware design, the orchard plant protection robot also needs to build an overall software and hardware system for debugging and experiments, in order to test the performance of the system. The system designed in this paper is set as the experimental group, and the traditional robot walking control system is set as the control group.

### 4.1 Experimental Environment

In the experimental process, the hardware device is firstly built. The ARM controller sends PWM control signal to the driver, which controls the motor rotation. The motor is connected to the reducer, and then to the encoder through the flexible coupling device. Program was written according to the flow chart of the speed ring control software. In the program, the sampling frequency was set to  $\_SOOHz$ , that is, the sampling time was 2 ms. The sampled data was stored in memory, and then the data in memory was read out to draw a curve with MATLAB for analysis.

First, execute the oscore command on the PC side to start the node manager; Second, Log on to the mobile robot computer through the PC SSH. Last, view the image on the PC.

The comparison between the walking control system of orchard plant protection robot based on artificial intelligence algorithm and the traditional robot walking control system (Fig. 4).



**Fig. 4.** Comparison of experimental results

Through experimental tests, it is found that the walking control system platform of orchard plant protection robot based on artificial intelligence algorithm achieves the expected effect of Motion control of the mechanical arm when it is controlled by keyboard, Leap Motion controller and PS2 wireless controller. From the perspective of operation effect and convenience, it is similar to the experimental effect of the walking subsystem. The operator is required to be familiar with the key function to achieve accurate operation by operating the mechanical arm movement through the keyboard.

This is the main problem existing in keyboard control, and its main advantage is good versatility. The main problems of Leap Motion control robot arm are poor operation stability, poor movement direction, and tiring operation time. Its advantage is that it can achieve contactless control effect. The PS2 controller is more stable and comfortable than the traditional robot walking control system.

## 5 Conclusion

Plant protection operation is the most labor-intensive and difficult to realize mechanized operation in the production of shed crops. However, with the development of China's urbanization, the situation of agricultural labor shortage appears, which directly leads to agriculture.

The rising cost of labor. Picking robot mainly solves the problem of labor substitution in the picking process. Its application can effectively reduce labor intensity and production cost, improve product quality and labor productivity. This paper is based on the research of the orchard plant protection robot walking control system based on the artificial intelligence algorithm. The work is mainly carried out in the following aspects: firstly, according to the research object, the targeted research and description of the parts to be used are carried out. Secondly, after the construction of the software and hardware platform, the walking subsystem is tested. The experimental results show that the control system platform has preliminarily achieved the expected control objectives.

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## References

1. Yang, S., Yang, X., Mo, J.: The application of unmanned aircraft systems to plant protection in China. *Precision Agric.* **19**(2), 278–292 (2018). <https://doi.org/10.1007/s11119-017-9516-7>
2. Dai, L.: Design of bionic robot action based on artificial intelligence algorithms. *Electron. Technol. Softw. Eng.* **131**(09), 262 (2018)
3. Anonymous: Gait parameter optimization algorithm of humanoid robot based on screw model. *Pattern Recogn. Artif. Intell.* **31**(11), 1018–1027 (2018)
4. Lu, Z., Lin, G., Lin, B., et al.: *Sci. Educ. Educ. J. (Late Decade)* **339**(5), 79–80 (2018)
5. Zhou, Z., Li, Y., Yan, R.: Design of orchard picking robot based on OFDM channel and remote monitoring. *Res. Agric. Mech.* **39**(3), 229–233 (2017)
6. Mao, F., Xu, H., Wang, Y., et al.: Orchard mobile robot path recognition system based on VB/Matlab. *Comput. Eng.* **43**(12), 315–320 (2017)
7. Leng, W.: Digital video optical fiber transmission system for orchard remote robot based on DWDM. *Res. Agric. Mech.* **41**(4), 215–218 (2019)
8. Tu, L., Li, L., Lin, G.: Study on global optimal path planning for orchard mobile robots. *J. Nanhua Univ. (Nat. Sci. Edn.)* **31**(4), 71–74 (2017)
9. Li, B., Li, H., Ge, Z.: Design of autonomous navigation orchard robot based on adaptive genetic algorithm and spline curve. *Agric. Mech. Res.* **39**(2), 47–51 (2017)

10. Liu, S., Lu, M., Li, H., et al.: Prediction of gene expression patterns with generalized linear regression model. *Front. Genet.* **10**, 120 (2019)
11. Luo, L., Zou, X., Lu, T., et al.: Virtual simulation and prototype test of picking robot operation behavior. *J. Agric. Mach.* **49**(5), 34–42 (2018)
12. Liu, S., Bai, W., Srivastava, G., Machado, J.A.T.: Property of self-similarity between baseband and modulated signals. *Mobile Netw. Appl.* **25**(4), 1537–1547 (2019). <https://doi.org/10.1007/s11036-019-01358-9>
13. Shuai, L., Gelan, Y.: *Advanced Hybrid Information Processing*, pp. 1–594. Springer, New York
14. Huang, L., Zhang, K., Hu, W., et al.: Trajectory optimisation design of robot based on artificial intelligence algorithm. *Int. J. Wireless Mobile Comput.* **16**(1), 35 (2019)