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Remote Operating System of Picking Robot Based on Big Data and WiFi

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Abstract: Fruit picking robots can automate fruit picking operations and solve the problems of labor shortage and high cost. Therefore, research on fruit picking robots is of great significance to reduce the cost of fruit picking. Here we mainly study the remote operating system based on big data and WiFi picking robot. This article first introduces the principles and architecture of big data Hadoop technology, then designs the picking robot motion model and positioning navigation model, and implements the picking robot positioning and navigation algorithm, and finally introduces the overall scheme and hardware design of the picking robot remote operating system. In this paper, a comparative study of the fruit stalk recognition method based on contour constraints and regional growth is conducted. The fruit stalk segmentation algorithm based on the region growth method can achieve fruit stalk segmentation under different lighting conditions, and the correct recognition rate of fruit stalks is 92.5%. The binding variable is the calculation of the color difference and color components of the target area of the fruit stem first. Under the conditions of direct light and backlighting and shading, the threshold of the fruit stem has a certain difference. There is a risk that the threshold selection is not accurate enough. The average correct recognition error is 87.4%. The experimental results show that the remote operating system can accurately control the movement of the picking robot in the middle of the fruit tree through the steering and movement control of the picking robot to successfully complete the picking operation, which meets the design requirements and has certain reference significance for the remote control of the picking robot.

1. Introduction

At present, due to technical and financial constraints, the picking work is basically done manually, with high labor intensity and low picking efficiency. Because the efficiency of manual picking often misses the best picking period of some fruits, resulting in the loss of fruit harvest. Fruit picking is the most time-consuming and laborious transformation in the entire fruit production chain, requiring a large labor force. However, in recent years due to the aging of the population and the growth of the urban industrial population, the labor force for agriculture and forestry has declined.

Therefore, reducing the fruit harvesting cost and eliminating the labor intensity of fruit farmers is an urgent solution to solve the problem in fruit production. Robot picking is the main trend to solve the above problems. Robotic picking technology can not only reduce production costs but also improve picking efficiency, replace human heavy and repeated manual labor, and work continuously, which can greatly improve and liberate the labor force.

In the wild environment, fruit images are easily affected by external environmental factors such as light changes, fruit size differences, and complex background noise. Traditional fruit recognition algorithms will reduce the accuracy of fruit recognition. Peng proposed an improved deep learning model for a single-shot fruit detector. He researched and proposed a detection method, using the ResN et-101 model to replace the VGG16 network in the classic SSD detection framework. After replacement, the framework still uses 6 feature extraction layers to predict the type and location of fruit objects on each layer. Then he used the transfer learning method to transplant the weight model under the large data set to the multi-fruit detection task. The SSD deep learning model is optimized by using the SGD (Stochastic Gradient Descent) algorithm. The pre-trained weight model on the ImageNet dataset is used as the initial weight model of the SSD detection framework, and further reduces the training time and resources by transferring the learned features. At the same time, data enhancement methods are used to improve the robustness of the algorithm without reducing the detection accuracy. Based on the Caffe deep learning framework, the fruit detection results of multiple types of fruit pictures collected using different network models, different data set sizes and different occlusion rates in the wild environment are compared [1]. His method has low recognition efficiency and cannot meet actual needs. Li G designed a picking robot vision system based on single chip microcomputer. His design has an autonomous navigation system equipped with a microcontroller unit and a global positioning system unit. The robot he designed has sensors and signal acquisition circuits suitable for its operating characteristics; therefore, it has various useful functions, such as image acquisition, target positioning, obstacle recognition, and position limit protection. Therefore, his robot has high intelligence and good perception of the external environment [2]. His method cannot identify and judge multiple fruits, and the method is still limited. Li D proposes a method of field navigation path extraction based on horizontal spline segmentation. First, he preprocesses the color image in the RGB color space through the OTSU threshold algorithm to segment the binary image of the groove. Using the HSV model's significant differences in hue and value, he divided the threshold into two steps. First, they split the lint in the S channel, and then split the furrow in the V channel outside the cotton zone. In addition, morphological processing is required to filter out small noise regions. Second, horizontal splines are used to segment binary images. He detects the connected areas in the horizontal spline and merges the isolated small areas caused by the bright spots in the cotton wool or nearby large connected areas to obtain the connected areas of the furrow. Third, based on the principle that the distance between adjacent navigation line candidates is small, starting from the center of the bottom of the image, the candidate points are selected in turn from the midpoint of the connected domain. Finally, he counts the number of connected domains and calculates the parameter changes of the boundary of the connected domains to ensure that the robot has reached the field or encountered obstacles. If there is no abnormality, the least square method is used to fit the navigation path from the navigation point [3]. His method is only for the collection of a certain product, and the recognition does not have diversity. In practical applications, it may produce serious discrimination errors.

The innovation of this article: This article combines the operating system and the fruit picking robot to realize a human-machine remote collaboration platform, give full play to the advantages of human being good at object recognition and robot good at execution, and improve the efficiency of fruit picking. On the dual-arm robot platform, fruit picking is a tightly coordinated task with dual arms, which requires high output speed and position accuracy of the drive unit. A distributed motion control system based on EtherCAT protocol was deployed to meet the requirements of the position servo control system. This paper implements a remote collaboration platform for humans and machines, implements an operating system and a fruit picking robot, exerts human's excellent object recognition ability and the robot's outstanding advantages, and improves the fruit picking efficiency.

2. Remote Operation Technology of Picking Robot

2.1. Cloud Computing

Cloud computing technology realizes hardware resource virtualization technology, and provides software and hardware resources to users through the network in a service manner. In this way, the universality of cloud computing technology is greatly enhanced, so that different users can Operation becomes simple.

(1) Virtualization technology

Virtualization technology refers to that data storage and calculation operations are performed on a virtual basis, rather than running on a real and visible machine. The purpose of this technology is to facilitate unified management and configuration of resources [4]. This technology can expand the storage capacity of the hard disk without reconfiguring virtual machines, reducing system expansion and supporting more operating systems [5]. The design idea of virtualization technology is to separate the software implementation layer from the hardware resources and must be independent. It supports the working mode of cutting a virtual resource into multiple virtual resources, which in turn can also combine multiple virtual resources into a virtual resource technology [6]. Virtualization technology is mainly to virtualize physical resources, which can improve the classification of system resources according to virtualization objects, and can be divided into storage virtualization, network virtualization and computing virtualization. At present, the main application areas of virtualization technology are CPU, operating system, server, etc., which has a great advantage in improving system efficiency.

(2) Distributed massive data storage technology

The cloud computing system is composed of many computers and provides a service to a large number of user groups at the same time. Therefore, the cloud computing system uses a distributed storage system to store data, and uses a copy storage mode to ensure the reliability of data resources. Sex. Data redundancy is achieved through task decomposition and aggregation, and low-configuration computers are used instead of high-performance computers. This method can reduce hardware costs and improve system reliability and security [7-8].

(3) Mass data management technology

Cloud computing systems need to deal with massive amounts of data, these large amounts of data need to be analyzed, processed, and calculated. Therefore, a technology that efficiently responds to massive data management is needed [9]. The data management technology of the cloud computing system mainly uses the data storage mode of the Hadoop team cloud computing system and the traditional RDBMS data management mode [10]. There is a big difference. The cloud computing system is the first to find the data that needs to be used in the huge database. issues that need resolving [11-12]. Because the traditional SQL database is not compatible with the Hadoop data storage mode, the previous data interface cannot be ported to cloud computing management. The currently studied Hadoop subprojects HBase and Hive can be applied to the current cloud computing system.

(4) Programming method

The cloud computing system uses a distributed computing model, so a distributed programming model Map-Reduce with a relatively simple idea is adopted [13-14]. The main working mode is to divide the job submitted by the user into pieces, and multiple data are calculated in parallel in parallel to the tasks assigned by the scheduler. In this programming mode, users can define the Map function and Reduce function by themselves, that is, they can customize the code to meet the specific needs of users [15]. Among them, the Map function is mainly to process the block data, and the Reduce function is a process that aggregates the intermediate results to calculate the final result and outputs it to the storage device.

(5) Cloud computing platform management technology

Cloud computing systems are faced with such huge data resources, the large number of servers and uneven distribution characteristics, how to efficiently and safely manage these servers is also an important challenge for researchers [16]. The ultimate goal of cloud computing platform management technology is to manage servers [17]. A large number of servers can work in parallel. Alternative deployment and management servers can detect system failure points in a short time, including high fault tolerance and high reliability [18].

2.2. Big Data

Big data technology mainly solves the problems of massive data storage, calculation and analysis. In the era of the Internet, cloud computing represents a data storage capability and computing power, and big data represents a data knowledge challenge. Cloud computing requires big data to reflect its more efficient computing power, and big data requires cloud computing to mine the valuable information it contains. Two aspects exemplify the relationship between big data and cloud computing: First, big data raises new demands on storage, computing, speed, and security, which makes cloud computing develop rapidly and continuously improve in terms of architecture, security, and storage. Promoting the further development of cloud services and cloud applications; the cloud computing services provided by the two vendors to users are flexible, convenient, cheap, scalable, and transparent in resources, so that users can easily build their own big data processing platforms on the cloud platform. With the help of cloud platforms, users can centrally store, manage, mine, and operate data [19].

For large amounts of data, distributed file systems and distributed database storage methods are usually used. Distributed storage is relatively relative to centralized storage. It was first proposed by Google. Its purpose is to provide the next Web access problem that is popular with large-scale concurrent scenarios through inexpensive servers. The existing mainstream distributed file system Hadoop distributed system HDFS (Hadoop distributed file system). The main feature of HDFS is that it can be deployed on the upper layer of cheap commercial hardware [20]. The large storage files with multiple terabytes or even PB are combed through the expanded storage point. It mainly supports the "write once, read many times" file operation tasks. As shown in Figure 1, it is a simplified model.

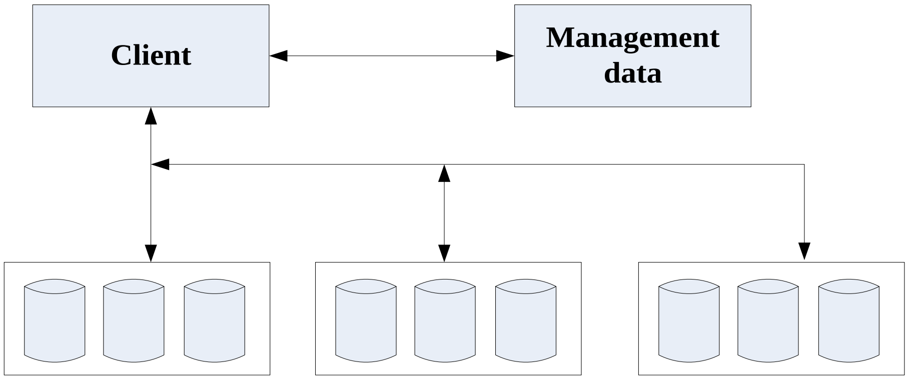

Figure 1. HDFS simplified model

HDFS generally uses a master/slave architecture. Each Hadoop is composed of a NameNode (used to manage the operation of the file system) and a DataNode (used to manage the upper-layer data storage of distributed computing) [21]. These HDFS elements combine to support applications with large data sets. HDFS originated from Yahoo and was used to meet some of the company's advertising services and search engine needs [22]. But it finds that users of the applications it needs to process have more and more access, and these users are generating more and more data. Later, companies such as Facebook, eBay and Twitter also started to use HDFS as the basis for big data analysis to solve the same needs. HDFS is usually used for large-scale deployments because it has an important feature, that is, it can run on ordinary cheap machines [23]. Also, for example, such a system running Web search and related applications often needs to be expanded to PB and several separate nodes, so the system must have easy-to-expand features, which formally made HDFS possible. Servers are very common at this scale, and the fault tolerance provided by HDFS is also of practical value in this regard [24].

HDFS cannot be used in scenarios with high latency requirements, such as real-time query. In terms of latency, HDFS does not have sufficient advantages. Second, HDFS is also difficult to support the storage of a large number of small files. In the Hadoop system, "small files" are usually defined as files that are much smaller than the block size of HDFS (at least 64MB) [25]. Since each file generates its own metadata, Hadoop uses NameNode to store this information. Many, it is easy to cause a large amount of NameNode memory, and it will also make seek HDFS suitable for time exceeding the read time, bringing performance improvement to the system. HDFS does not support multi-user writing, nor can it randomly modify files. It only supports appending, that is, appending to the end of the file. For storing semi-structured and unstructured data, if there are strict structured characteristics of the data, it is appropriate to use HDFS forcibly. HDFS is suitable for TB and PB-level big data processing. The amount of file data is usually more than one million. If the data the volume is very small, there is no need to adopt HDFS [26].

2.3. Coordinate System and Kinematics Forward and Inverse Solutions

The joint part of the robot's coordinate system and the world coordinate system adopt the right-hand principle. The coordinate system of the selected binocular camera is the left-hand principle. In order to make it compatible with the right-hand principle coordinate system adopted in this topic, the y-axis is reversed here [27]. The coordinate system of the lumbar joint of the world coordinate system coincides, the rotation auxiliary coordinate system is parallel to the xy plane of the world coordinate system, the x-axis of the left and right arms rotates relative to the x-axis of the world coordinate system by $+45°$ and $-45°$, the robot arm is in The lowest point is $Z_l = 0$ and

$Z_r = 0$. Assuming that the root coordinate systems of the left and right arms coincide with their own shoulder coordinate systems, the conversion matrices of the left and right arm root coordinates to the world coordinate system are:

$$^{w}T_l = Rot\left(z,-\frac{3\pi}{4}\right)\cdot Trans(-199.82,27.82,150) = \begin{pmatrix} -0.707 & 0.707 & 0 & 160.966 \\ -0.707 & -0.707 & 0 & 121.622 \\ 0 & 0 & 1 & 150 \\ 0 & 0 & 0 & 1 \end{pmatrix} \quad (1)$$

$$^{w}T_r = Rot\left(z,-\frac{\pi}{4}\right)\cdot Trans(-199.82,27.82,150) = \begin{pmatrix} 0.707 & 0.707 & 0 & 160.966 \\ -0.707 & 0.707 & 0 & 121.622 \\ 0 & 0 & 1 & 150 \\ 0 & 0 & 0 & 1 \end{pmatrix} \quad (2)$$

The conversion matrix of the binocular camera to the world coordinate system is:

$$^{w}T_c = Rot(z,\pi)\cdot Rot\left(z,\frac{\pi}{2}\right)\cdot Trans(60,-60,557.5) = \begin{pmatrix} -1 & 0 & 0 & -60 \\ 0 & 0 & -1 & -557.5 \\ 0 & -1 & 0 & 60 \\ 0 & 0 & 0 & 1 \end{pmatrix} \quad (3)$$

For convenience of description, the coordinates and angles discussed below are relative to the arm root coordinate system [28]. In actual use, the coordinate can be converted to the world coordinate system by multiplying the coordinate by the corresponding conversion matrix. Suppose that each of the elbow joint and the shoulder joint rotates θ_1 and θ_2, and the x and y of the coordinates can be obtained by the following positive kinematic equations (4) and (5).

$$x = l_1 \cos\theta_1 + l_2 \cos(\theta_1 + \theta_2) \quad (4)$$

$$x = l_1 \cos\theta_1 + l_2 \sin(\theta_1 + \theta_2) \quad (5)$$

If two rectangular coordinates x and y are known, the corresponding joint coordinates θ_1 and θ_2 can be obtained by the following inverse kinematic formulas (7) and (8).

$$(r,\phi), r = \sqrt{x^2 + y^2} \quad (6)$$

$$\theta_2 = \pi \pm \alpha, \alpha = \arccos\left(\frac{l_1^2 + l_2^2 - r^2}{2l_1 l_2}\right) \quad (7)$$

$$\theta_1 = \arccos\left(\frac{y}{x}\right) \pm \beta, \beta = \arccos\left(\frac{r_1^2 + l_1^2 - l_2^1}{2l_1 r}\right) \quad (8)$$

3. Experimental Design of Remote Operating System for Picking Robot

3.1. Experimental Environment

The experiments in this article are done on a Hadoop cluster, and to create a more suitable cluster environment requires a lot of hardware and software installation and settings, a NameNode and multiple DateNode are required. The master node NameNode is the manager of the distributed file system, and the experimental data user behavior monitoring data is stored in the data node DataNode. The hardware configuration of this experiment is a dimensional vision industrial camera and a checkerboard calibration board. The algorithm of this experiment is based on the open source OpenCV vision library and C++ language. The software platform of this experiment is Visual Studio2010.

3.2. Pretreatment

The image acquisition process is inevitably subject to noise interference caused by the external environment, such as the electromagnetic wave interference of the external electrical equipment of the system and the internal clamping circuit of the system. These noises have an adverse effect on subsequent image segmentation and image recognition. Therefore, in order to obtain a good segmentation effect, image noise processing is a step that cannot be ignored. Image noise is theoretically random and unpredictable and cannot be completely eliminated. Gaussian, median, and mean filters are often used to reduce noise in images. Both the mean value and Gaussian filter obtain the noise reduction effect by calculating the average value of each pixel and the pixels in the neighborhood instead of the value of the center point. They are all linear filters that will blur the details of the image. The difference is that the former uses simple average and the latter uses weighted average. Median filtering can both reduce noise and protect the edges of the image. It is a nonlinear filtering method. Median filtering is to replace the value of the pixel with the median of the neighborhood.

$$g(x,y) = median(\upsilon_1, \upsilon_2, ..., \upsilon_n) \quad (9)$$

Where $g(x,y)$ is the pixel of the generation filter, $\upsilon_i | i = 1,2,...,n$ is the value of the neighboring pixels. The median filter on the image is sensitive to the shape and size of the filter window, and should be selected according to the actual application. Too large a window will blur the edge of the image, while too small will cause an unsatisfactory filtering effect. Generally, the filter window is selected by the experimental method, and the window is gradually enlarged from 3×3 (generally the odd-order window is selected) until the filter effect is satisfied.

3.3. Experimental Design

After considering a variety of communication network configurations for the monitoring and control system of the picking robot, a heterogeneous communication system with different hardware architectures is used, that is, the WiFi module is used to realize the communication between the background PC and the picking robot terminal. The WiFi module can work in AP mode and STA mode, and it can be connected to the control circuit board of the picking robot and work in STA mode. The WiFi module needs to establish a socket network connection with the local area network to realize the communication between the picking robot and the PC.

During the experiment in the orchard, always keep the arm at a 45° angle to the horizontal ground, and manually break, pull, twist and pull + break the apples in the posture range [-45°, 45°]

Action, pull + twist action, twist + break action; during the experiment, keep the action speed and time consistent with the simulation experiment, each action experiment sample is 100 different postures, and the stiffness of the branches is close to the fruit.

First, the camera takes multiple images of the calibration board and stores them. It should be noted that the attitude of any two calibration boards cannot be parallel. In this experiment, a total of 11 images of calibration plates with different poses were taken.

The program sequentially reads the calibration board image and extracts the corner information on the image based on the Harris corner detection algorithm, and uses the above corner information as the initial value to further determine the corner information of the calibration board image under the sub-pixel.

According to the camera calibration algorithm in this paper, the internal parameter matrix, distortion parameter and external parameter matrix of the camera imaging model are calculated. At the same time, in order to check the accuracy of the camera calibration result, 11 calibration plate images are calculated based on the internal and external parameter matrix and distortion parameters in the calibration result The average re-projection error of all corners on the table is shown in Table 1.

Table 1. Camera calibration results

Camera internal reference matrix	Distortion parameter	Average reprojection error
$\begin{bmatrix} 3277.8947 & 0 & 492.8742 \\ 0 & 3277.9875 & 236.6547 \\ 0 & 0 & 1 \end{bmatrix}$	[-0.3378 1.3248]	0.6347

4. Experimental Analysis of the Remote Operating System of the Picking Robot

4.1. Picking Performance Analysis

The remote operation system of the picking robot, the main function is that the picking robot collects its geographic location and motion status information, and then sends it to the background PC through WiFi wireless communication; the background PC uses big data Hadoop technology to analyze the motion status of the picking robot. Realize the real-time positioning of the picking robot and provide information guidance for the navigation of the picking robot. In addition, a mobile terminal remote control application APP has been developed, which can control the movement of the picking robot through the mobile phone. In order to verify the stability and feasibility of the remote operating system for picking robots based on big data and WiFi, the system was verified.

Through simulation analysis, it is found that comparing the different picking actions, the torque and shear force generated are different. Under the various attitude angles of the apple, the breaking action with good picking performance cannot fully achieve the force and torque generated by the action. The picking torque threshold and shearing force threshold are analyzed, and it is found that the rigidity of the branches is selected as shown in Figure 2 due to the small selection of the rigidity of the branches. Field survey of fruit trees in orchards shows that the proportion of fruits in the above growth conditions in the whole tree is about 5%-10%. Due to the low rigidity of the branches, the picking success rate is low. In the process of manually picking apples, for different picking actions, the apple picking efficiency and picking success rate are different. Simulation analysis and field experiments show that factors such as branch stiffness, constrained position, picking speed, and fruit posture will affect the apple picking success rate and picking efficiency. The stiffness of the branches is the stiffness of the branches connected to the apple stalks. During the picking process, the different stiffness of the branches will cause different deflections of the fruit stalks and branches. And picking efficiency. The constrained position refers to different positions where the fingers are pressed against the fruit stems during manual apple picking. Picking speed refers to the different rates of fruit picking. Fruit posture refers to different growth postures of the fruit in the natural environment, and the picking action has different effects on picking fruits of different postures. The effects of these factors on apple picking performance are discussed below.

Figure 2. Apple connected to a less rigid branch

As shown in Table 2, the picking success rate of the constrained breaking motion is higher than that of the unconstrained breaking motion, and the damage rate is lower. The experimental results are in good agreement with the simulation situation, and the influence of the constraints on the picking performance is verified. The picking success rate of the pulling action and its compound action is low, and the stemless rate is high. The reason is that the connection between the freshly ripe apple fruit stalk and the fruit is weak, and the pulling action is easy to separate the fruit stalk from the fruit. The twisting action and the compound action increase the sessile-free rate of the fruit, which is not conducive to fruit picking. To sum up, the experimental results of the manual picking operations are in good agreement with the simulation analysis results of the previous chapters, which illustrate and verify the reliability and rationality of the apple picking process dynamic model.

Table 2. Statistical table of experimental results of picking action

	Break (Unconstrained)	Break (Constraint)	Twisting action	Pull action	Pull + Break	Pull + Twist	Twist+Break
Success rate	47.6%	93.7%	53.7%	9.8%	65.2%	61.0%	63.5%
Failure rate	0.0%	3.9%	15.0%	0.0%	20.7%	10.7%	3.7%
Infarct rate	52.4%	2.4%	31.3%	90.2%	14.1%	28.3%	32.8%

4.2. Analysis of Positioning Error of Vision System

As shown in Table 3 and Figure 3, the three binocular vision systems can accurately identify fruits, with a recognition rate of 100%. In the world coordinate system, the absolute value of the distance deviation of the Logitech C270 camera is less than 2mm, and the absolute value of the distance deviation of the PMD camera and GS3-U3-15S5C camera is less than 1mm. According to the accuracy requirements of the fruit picking robot, considering the high cost of the PMD camera, With the characteristics of large quality, GS3-U3-15S5C camera is the best choice.

Table 3. Position errors of three vision systems

Different types of cameras	Vision system target measuring distance/mm		Manually measure the target distance/mm		Absolute error/mm	
	Goal 1	Goal 2	Goal 1	Goal 2	Goal 1	Goal 2
PMD camera + Logitech	93.48	103.47	93.69	102.84	0.22	0.63
C920	142.69	143.79	142.62	142.55	0.13	1.32
Logitech C270	135.64	138.21	135.82	139.32	0.22	0.79

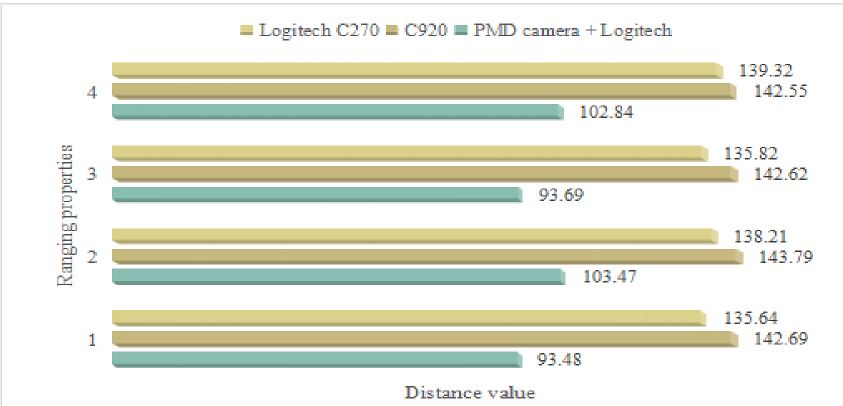

Figure 3. Position error of three vision systems

4.3. Analysis of Measurement Error of Laser Sensor

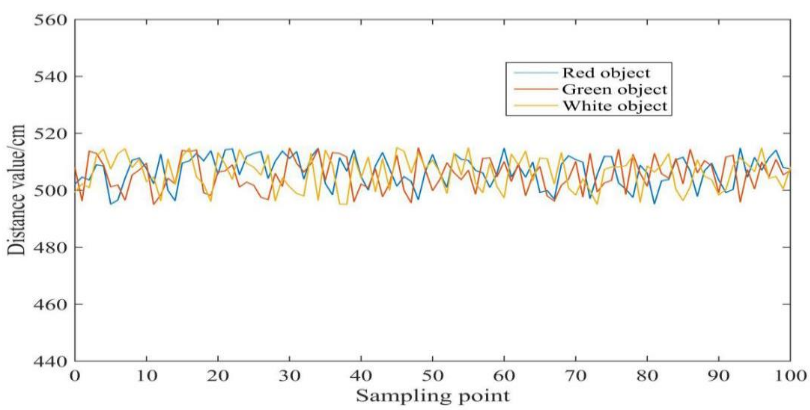

Figure 4. Distance values measured by objects of different colors

Since the laser sensor calculates the distance based on the round trip time of the pulse reflected by the laser, its internal response accuracy, the surface characteristics of the target object and the laser spot size directly affect the measurement accuracy of the LMS511 sensor. The errors of the laser range finder are divided into system errors and statistical errors, which are: System error: According to the LMS511 technical data provided by SICK, under standard resolution conditions, the maximum system error is ±50mm. Under high-resolution conditions, the maximum system error is ±35mm. Statistical error: This error includes the influence of parameters such as surface characteristics of different objects, laser spot size and different target distances on the statistical error of laser sensor ranging. According to the technical data, under standard resolution conditions, the statistical error is up to ±14mm. Under high-resolution conditions, the maximum system error is ±9mm. In order to more accurately describe the statistical error of the laser sensor, combined with the actual situation of the tomato picking environment, multiple measurements were made on objects of different colors and different distances to obtain statistical errors, and verify whether the selected laser sensor LMS511 meets the needs of tomato picking. First, measure objects of different colors. Place red, green, and white objects on the front of the laser sensor, fixed at a position of 5m, and measure 100 times. And compared with the actual position of the object, the distance measurement result is obtained. As shown in Figure 4, the color of the object is different, and the error of distance measurement is also different. After calculation, the standard deviation of the distance measurement of the red object is 0.48cm, and the distance of the green object The standard deviation of the measurement is 0.39cm, and the standard deviation of the white object distance measurement is 0.26cm, indicating that the red measurement error is slightly larger than the green and white, and the white measurement error is the smallest. In the tomato plantation, the objects located in front of the laser sensor will generally be close to the white ground, red ripe tomato fruits and green immature fruits and branches and leaves. From the numerical point of view, the statistical error is less than 1cm. The error has little effect. In order to check the effect of different distances on the measurement accuracy of the laser sensor, the same object is measured at different distances, respectively 2m ~ 20m, with an interval of 2m, each measurement 10 times, calculate the average error, the measurement results are shown in Figure 5. It can be seen from the figure that as the distance increases, the average error of the laser sensor shows an upward trend, but the standard deviation remains within a certain range, the average value of the standard deviation is 0.26cm, although the average measurement error increases with the distance, However, the standard deviation at different distances is less than 1cm, indicating that the stability of the laser sensor is good.

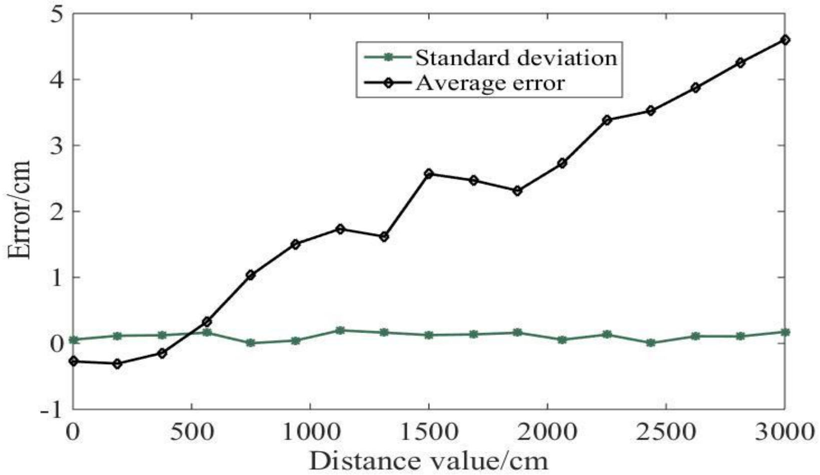

Figure 5. Measurement error at different distances

5. Conclusion

In this paper, the motion control system based on the EtherCAT protocol is deployed based on the characteristics of the two robot arms of the dual-arm robot that are closely cooperative in fruit picking. According to the characteristics of the EtherCAT protocol, the motion control system is determined to be a linear structure, the overall framework of the motion control system is given, and the hardware resources and selected hardware required by the framework are introduced. The procedure and realization process of the upper computer program design are introduced in detail. The tracking performance of the motion control system was tested using EAS. Tests show that the system's position tracking performance is very good, the position tracking accuracy is ±3 encoder pulses, and the static deviation can be controlled within ±1 pulse, meeting the requirements of the position servo control system. The servo system's speed tracking is not very ideal, and the dynamic deviation of the low-speed test is within ±5%.

Due to the high frequency and difficulty of hand-eye calibration of fruit picking robots, an automated hand-eye calibration system for fruit picking robots was designed. The system only needs a few simple manual operations in the process of hand-eye calibration, which reduces the difficulty of hand-eye calibration of the fruit picking robot. There are three modules in the system, including the collection of calibration data, the planning of the movement of the robot arm, and the execution and termination of the calibration algorithm. This article details the functions of each module and the workflow of the system. The work flow of the robotic arm motion planning module is introduced in detail. The position and posture of the end effector planned by this module can ensure that the calibration plate is within the field of view of the camera with a high probability, which is the key to the automatic hand-eye calibration of the fruit picking robot. The experiment was conducted on the fruit picking robot platform. The test data showed that the system can quickly and effectively achieve the hand-eye calibration of the fruit picking robot, which reduces the difficulty of manual use and increases the practicability of the fruit picking robot.

In this paper, based on big data, wireless WIFI and embedded control technology, a set of remote operating system for picking robot based on big data and WiFi is designed to realize the mutual communication between PC and picking robot. When working, the picking robot sends its position and motion information to the background PC. The PC uses big data Hadoop technology to analyze the running status of the picking robot and provide reference information for the remote control of the picking robot. In this paper, the picking robot can successfully complete the picking operation, which meets the design requirements.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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