DESIGN AND TEST OF SORTING DEVICE BASED ON MACHINE VISION

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ABSTRACT

At present, the sorting of agricultural products in China mainly relies on manual labor, which results in low efficiency, and the development of corresponding automatic equipment lags behind. The grasping method based on machine vision has been widely used in industry, and can provide a reference for the automatic sorting of agricultural products. In this paper, an automatic sorting device for agricultural products was designed. The grasping mechanism adopted a 4-degree-of- freedom (4-DOF) manipulator, and the machine vision control system adopted a monocular camera, which can realize the positioning and classification of the grasp-target. First, the geometric model of the manipulator was established, and the kinematics model of the manipulator was established via the Denavit-Hartenberg (D-H) parameter method. Next, the kinematics analysis and verification were carried out. Then, Zhang Zhen you calibration method was used to calibrate the camera. An image processing method based on histogram correction was proposed. Based on this, a target positioning algorithm based on the pinhole imaging principle and a target classification algorithm based on the area threshold were established. Finally, an automatic sorting test platform for agricultural products using a visual servo was built. Target classification, positioning and sorting tests were conducted using tomatoes and oranges as the test objects. The test results show that the success rate of the target positioning is close to 98%, that of the target classification is close to 98% and that of the grasping is close to 95%. Furthermore, the sorting time of a single target object can be as fast as 1 second, which can meet the requirements of automatic sorting for common agricultural products. The automatic sorting device for agricultural products has a simple structure, reliable performance and low costs. The structure and algorithms proposed in this paper are simple, reliable, and highly efficient and thus can easily realize technology transplantation. These relevant methods provide a theoretical reference for the development of an automatic sorting device for agricultural products.

Keyword: *Object Sorting, Arduino, Servo Motor, Image Tracking, Machine Vision.*

1. INTRODUCTION

Robots are typical mechatronics equipment. It benefits from the latest research results of many subjects, such as micro-electronics and computers, automatic control and driving, and artificial intelligence. In recent years, robots have played increasingly important role in scientific research and engineering applications. It has become a common industry practice to use robots to reduce labor costs and improve operating efficiency.The application range of robots has expanded from the traditional industrial field to many aspects, such as the service industry and

agriculture. However, because of their relatively simple perception and recognition, traditional robots can only be used in some specific environments. In the field of robotics, a machine vision control system can make a robot move more flexibly and faster. With the developments in computer technology, image processing technology and control theory, a robot machine vision system can integrate visual data into the controller and provide feedback control signals for the robot controller

It will improve the control performance and make the robot's actions more flexible, including robot assembly, driverless cars, robot tracking, detection systems, etc. Due to the advantages of large amounts of information, strong perception and high reliability, vision sensors have been widely used in robot control systems. Therefore, robots based on machine vision have gradually become one of the active research directions

Due to the continuous improve the control performance and make the robot's actions more flexible, including robot assembly, driverless cars, robot tracking, detection systems, etc. Due to the advantages of large amounts of information, strong perception and high reliability, vision sensors have been widely used in robot control systems Therefore, robots based on machine vision have gradually become one of the active research directions. Robots have been widely used in industrial automation production processes. And they can improve production efficiency and ensure product accuracy. For example, industrial robots have been commonly used in industrial production for sorting. Robots based on machine vision have fewer applications in agriculture, and there is no relatively mature sorting device for agricultural products. At present, sorting agricultural products is labor-intensive, but it mainly relies on manual labor that has with low efficiency and high costs. Compared with industrial robots, agricultural robots have lower precision requirements, and so a simple algorithm can meet its requirements. A simple algorithm can reduce the costs and improve the efficiency via its simple operation.

1.2 Problem Definition

At present, the sorting of agricultural products in China mainly relies on manual labor, which results in low efficiency, and the development of corresponding automatic equipment lags behind. The grasping method based on machine vision has been widely used in industry, and can provide a reference for the automatic sorting of agricultural products. In this paper, an automatic sorting device for agricultural products was designed. The grasping mechanism adopted 4-degree-of- freedom(4-DOF) manipulator, and the machine vision control system adopted a monocular camera, which can realize the positioning and classification of the grasp-target. First, the geometric model of the manipulator was established, and the kinematics model of the manipulator was established via the Denavit-Hartenberg (D-H) parameter method.

2. Project implementation

Robots are typical mechatronics equipment. It benefits from the latest research results of many subjects, such as micro-electronics and computers, automatic control and driving, and artificial intelligence. In recent years, robots have played increasingly important role in scientific research and engineering applications. It has become a common industry practice to use robots to reduce labour costs and improve operating efficiency Due to the continuous developments in science and technology, the application range of robots has expanded from the traditional industrial field to many aspects, such as the service industry and agriculture. However, because of their relatively simple perception and recognition, traditional robots canonly be used in some specific environments.

Fig 2.1 Color base sorting machine

2.1 Tools and technologies Used

The sorting operation mainly includes three processes: positioning, classification and grasping. Several oranges are placed by randomly throwing them into the target recognition area, and the target positioning algorithm and the target classification algorithm are applied. Then, the target objects are positioned and classified, and the manipulator uses the positioning information to grasp the classified target objects, thereby completing the sorting operation. A total of 180 sorting tests were carried out for oranges at random locations.

The test results show that for different sized oranges placed at random locations, the positioning success rate is close to 98%, the grasping success rate is close to 94%, and the sorting success rate is close to 93%. The sorting device has a high sorting success rate and reliable performance. Furthermore, it can meet the requirements of automatic sorting for agricultural products.

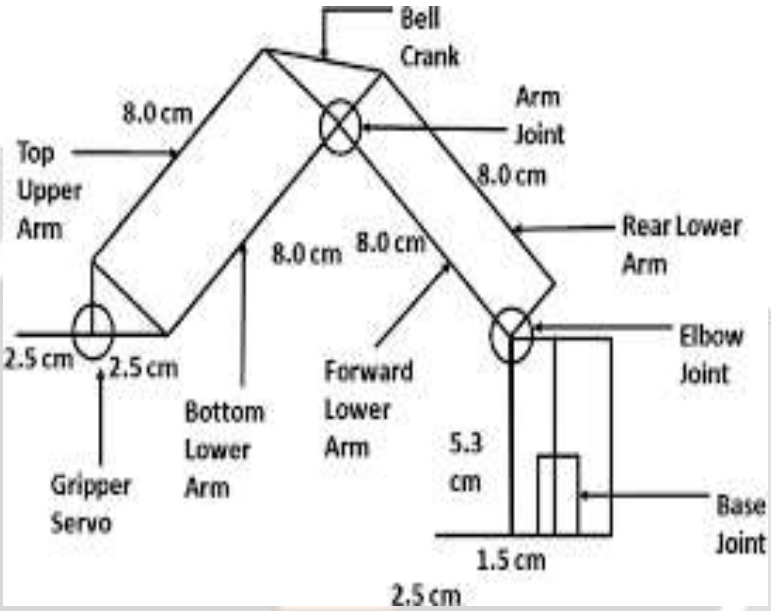

Figure 2.1.1 Computer vision based robotic arm controlled using interactive GUI

2.2 Advantages

- Simple and easy to understand and use.
- Clearly defined stages.
- Easy to arrange tasks.
- Works well for smaller projects

3. Software and Hardware Requirements Specification

It can describe both shape and texture features, which are essential elements for content-based image analysis. Its importance makesthe edge to be one of the most frequently used image features for the content-based image analysis, demanding a standardized means for its description. In MPEG-7, the edge description in an image is standardized in terms of edge histogram descriptor (EHD). The EHD describes five edge types in the image, namely horizontal, vertical, two diagonal, and non-directional edge types. Population for these five types of edges in a local image region ofa sub-image is represented by a histogram with five bins. Specifically, the image space is divided into 16 (4 × 4) non-overlapping sub-images and for each sub image a histogram with five edge bins is generated, yielding a combined edge histogram with 80 (16×5) bins for the entire image.

3.1 Hardware requirement

Arduino, pick and place robot used Its function is to control the Arduino control board, process the images captured by the CCD camera, and calculate the motion parameters of the manipulator. The Arduino control board that connected with the servo control board receives the control signal of the upper computer, and then controls of the servo.

3.2 Software requirement

C sharp, visual studio 2017 used. The software system can be divided into the three parts: image processing module, motion processing module and pose transformation module. The image processing module is used to obtain the target image and then transmit the target image to the upper computer.

4.Project Scope

The scope of this project saves human efforts and time ,order data management it is a growing technology, helpful for growing the business. Its function is to control the Arduino control board, process the images captured by the CCD camera, and calculate the motion parameters of the manipulator. The Arduino control board that connected with the servo control bord receives the control signal of the upper computer, and then control. Then gular deviation of the servo motor includes the return error of 0◦ and the left and right errors of≤3◦. The servo is a closed-loop control system with a fast respondentia precision. The servo of the detection circuit can judge the turning angle using a potentiometer and adjust the servo rotation according to the deviation. The sorting of agricultural products does not require high precision, so there is no need to measure the joint angle again.

Manually grading is costly and grading operation is affected due to shortage of labor in peak seasons. Human operations may be inconsistent, less efficient and time consuming. New trends in marketing as specified by World Trade Organization (WTO) demand high quality graded products. Farmers are looking forward to having an appropriate agricultural produce like Guava Fruit grading machine in order to alleviate the labor shortage, save time and improve graded product's quality.

1. Saving Manpower
2. Improving quality and efficiency
3. Ability to work long time in any hostile environment

5.System Implementation Plan

Activity	I week	II week	III week	IV week	V Week	VI week	VII week	VIII week	IX week
	Aug 4	Aug 11	Aug 18	Aug 25	Sept 1	Sept 8	Sept 15	Sept 22	Sept 30
Initiate the project									
Communication									
Literature survey									
Define scope									
Develop SRS									
Plan the project									
Design mathematical model									
Feasibility Analysis									
Develop work breakdown structure									
Planning project schedule									
Design UML and other diagrams									
Design test plan									
Design risk management plan									

Timeline Chart-1

Activity	XI week	XII week	XIII Week	XIV week	XV week	XVI week	XVII week	XVIII week	XIX week	XX week	XXI week	XXII week
	Jan 5	Jan 15	Jan 19	Jan 26	Feb 2	Feb 9	Feb 16	Feb 23	Mar 2	Mar 9	Mar 16	April 25
Execute the project												
Build and test basic functional unit												
Build and test database with login and session maintenance facility												
Designing of 1st and 2th module												
Testing of 1st and 2nd module												
Designing of 3rd and 4th module												
Testing of 3rd and 4th module												
Integration of all module												
Final Report and Presentation												

Timeline Chart-2

6.Future Scope

The machine learning techniques with adequate concepts of image processing have a great scope to provide intelligence for designing an automation system to differentiate the fruits according to its type, variety, matureness and intactness. Using the concept of an intelligent AI-based system using spectrophotometer and computer vision, an automated fruit segregation based on their grade can also be designed. There will be 95% accuracy, using a cloud-computing platform provided by Microsoft Azure. After that, using spectroscopy and ensemble machine learning approaches, fruit grade can be predicted.

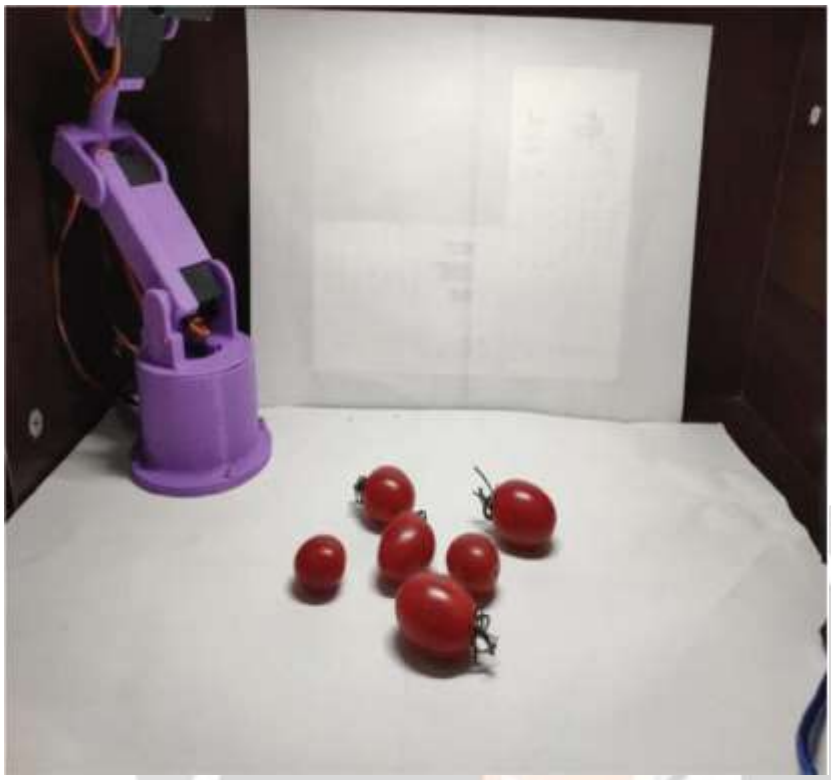

Fig6.1 Target positioning and grasping test.

7. CONCLUSIONS

An automatic sorting device for agricultural products was designed. The grasping mechanism adopted a 4-DOF manipulator, and the machine vision control system adopted a monocular camera. The device can realize target positioning and classification based on image processing. The automatic sorting device has a simple structure, reliable performance and low costs, and it can realize the positioning, classification and grasping of target objects. The geometric model of the manipulator was established, and then the kinematics model of the manipulator was established via the D-H parameter method. A target positioning algorithm based on the pinhole imaging principle and a target classification algorithm based on the area threshold were established, and these algorithms were verified by tests. The results show that the proposed algorithms can realize target positioning and classification. An automatic sorting test platform for agricultural products based on a visual servo was built. The target classification, positioning and sorting tests were carried out using tomatoes and oranges as the test objects. The test results show that the success rate of target positioning is close to 98%, that of target classification is close to 98% and that of grasping is close to 95%. Furthermore, the sorting time of a single target object can be as fast as 1 second, which can meet the requirements of automatic sorting for common agricultural products.

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