Advances in Computer Science Research, volume 89
2019 International Conference on Wireless Communication, Network and Multimedia Engineering (WCNME 2019)

Intelligent Tennis Picking Robot Based on STM32 and Raspberry Pi

Shiqian Zhang[1], Yizhun Peng[2,*], Zhenjiang Chen, Di Li and Zhou Zhang
[1]College of Electronic Information and Automation, Tianjin University of Science and Technology, China
[2]Advanced Structural Integrity International Joint Research Centre, Tianjin University of Science and Technology, Tianjin, 300222, China
[*]Corresponding author

Abstract—The robot involves a smart tennis picking robot based on STM32 and Raspberry Pi. The mobile robot body is formed by sheet metal forming. The driving method is three-wheel independent driving, and three hollow cup DC servo motors are respectively controlled by three. An omnidirectional wheel. The robot is divided into a chassis motion control portion, a visual processing portion, and a tennis collection portion. The chassis control section is located at the bottom of the robot, including the servo drive, battery, main control board, HC05 Bluetooth module, two ultrasonic obstacle avoidance sensors and three hollow cup DC servo motors. The visual processing part consists of a raspberry pie and a camera. The tennis collection section includes a tennis collection structure and a storage box. The STM32 controller interacts with the servo drive via the CAN bus, enabling the robot to move omnidirectionally with zero radius of rotation. At the same time, the Raspberry-based Haar-based image recognition program and camera can accurately identify the tennis target position. Ingenious science solves the problem of time and labor for manual tennis picking.

This paper introduces the overall mechanical structure of the robot, describes the mechanical structure of the chassis and tennis collection part and the advantages and reasons for selecting the robot control hardware. Starting from the image recognition part, the tennis recognition processing program combining Haar classifier and CamShift algorithm is described in detail by modularization. Finally, the advantages of the design product and the future development of other functions of the robot are summarized.

Keywords—tennis picking; raspberry Pi; STM32; haar; CamShift

I. INTRODUCTION

Nowadays, more and more people are engaged in the army of sports. Tennis is a very popular competitive sport and attracts a large number of fans. Because the tennis court has a large area and a fast ball speed, people also consume a lot of physical strength because of the running. Therefore, it is a very painful thing for tennis players to smash tennis. At present, there is no service or product specializing in intelligent tennis picking robots in China, which belongs to the market to be developed. At the same time, the Chinese market has great potential. There are about 85,475 tennis courts and 8.64 million tennis players, and the number of sports people is growing at an annual rate of 10% to 12%[1]. At present, there are a small number of caddies specializing in tennis croquet on the market, and the quality of personnel is poor. Most of them are temporary employment of tennis courts[2]. Therefore, designing such an intelligent tennis picking robot based on omnidirectional mobile platform is of great significance for tennis training. The introduction of this intelligent robotic product on the tennis court not only saves money, but also satisfies the pursuit of fashion for tennis lovers.

II. MECHANICAL STRUCTURE AND CONTROL HARDWARE

The smart tennis picking robot chassis is formed by sheet metal forming, and the outer dimensions are 365.5×400.2×109. The wheels used are omnidirectional wheels. And the overall chassis structure is shown in Figure 1.

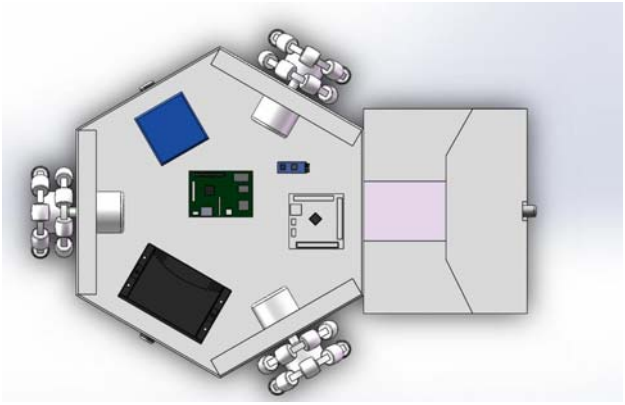

FIGURE I. CHASSIS STRUCTURE

The use of such a chassis structure makes the robot more flexible and can achieve three degrees of freedom (horizontal, vertical and rotational) motion in either plane[3]. The maximum moving speed of the robot is 0.65m/s, the maximum rotation speed is 200°/s, and the minimum turning radius is 0m. Due to its low ground, it is suitable for indoor and outdoor tennis courts. The battery life is about 10h and the standby time is more than 30h.

At the front of the robot is a tennis collection structure consisting of a collection of forearms, tracks and brushes. The forearm is collected at the foremost end of the collecting structure, followed by the ascending track, and a brush and a motor are fixedly mounted on the upper side of the ascending track for moving the tennis ball from the track to the tennis receiving case on the upper side of the robot.

When collecting tennis balls, first collect the forearms to increase the collection range and improve the collection efficiency. At the same time, the collected tennis balls are fed onto the track by the rotating brush driven by the motor, thereby entering the tennis receiving box. The receiving box and the chassis control layer are separated by a laterally mounted partition and fixed to the tennis collecting structure by a groove for easy disassembly. The tennis collection structure is shown in Figure 2.

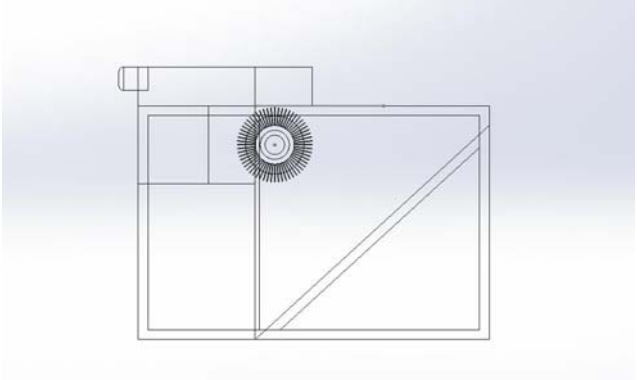

FIGURE II. TENNIS COLLECTION STRUCTURE

The STM32f407 and an ARM-based servo drive are used to control the chassis motion in terms of control hardware. The STM32f407 is a high-performance 32-bit processor with a 168MHz clock speed and 210DMIPS processing power[4]. At the same time, with the servo driver used as the control core of ARM, complex control algorithms can be realized, which reduces the volume of the system and increases the reliability of the system. The servo driver workflow is shown in Figure3.

The control core used in image processing is the Raspberry Pi. Run the opencv software on the Linux system it is running on. Low power consumption, small size, low cost and high computing power make it an important reason for this robot image recognition processing center[5,6].

III. ALGORITHM FLOW

The robot uses the Haar Cascade Classifier combined with the CamShift algorithm to realize the recognition and tracking function of the tennis ball. The CamShift algorithm can quickly and efficiently track objects with fast target changes in the video, with accurate positioning, small algorithm complexity and good robustness[7]. After analyzing and comparing with several other algorithms, it is determined that the CamShift algorithm is used to realize the detection and recognition of tennis balls based on the dynamic target color histogram[8].

The Haar Cascade Classifier is a supervised learning classifier. To detect an object, first perform histogram equalization on the image and normalize it to the same size[9], and then mark whether it contains the object to be detected. When the image captured by the camera contains tennis, the robot recognizes the tennis ball and executes CamShift. The algorithm calculates the deviation direction of the tennis ball from the video center, thereby controlling the steering of the robot. When reaching the center line of the screen[10], the robot advances to the tennis ball, and the tennis picking mechanism picks up the tennis ball into the collecting box. The program flow is shown in Figure 4.

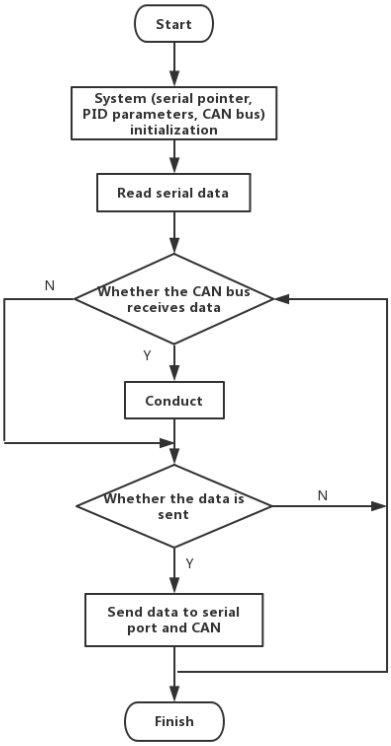

FIGURE III. SERVO DRIVE WORKFLOW

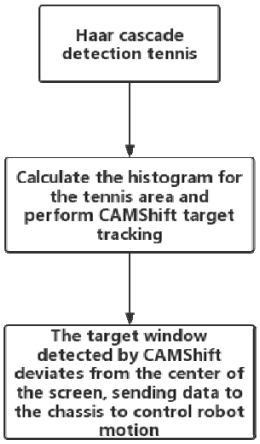

FIGURE IV. PROCEDURE FLOW CHART

IV. SUMMARY

In view of the continuous popularization of tennis and the main problems in daily tennis, this paper mainly designs a smart

tennis picking robot, which is designed from the mechanical structure and hardware selection to the system program. Finally, the design of the whole robot is completed. The main function of the structure is to pick up and collect the tennis balls scattered in the tennis court by the robot, and solve the problem of time and labor for manual tennis picking.

The robot has the following features: First, the chassis motion control with high flexibility and high accuracy, the omnidirectional movement and the turning radius are zero through the omnidirectional wheel and the mechanical structure. The second is to separate the chassis motion control from the image recognition processing, and use STM32 and Raspberry Pi as the control centers of these two parts respectively to realize the separation of decision and control, make the system more stable and reliable, and develop more convenient. Third, the tennis pick-up mechanism is exquisitely designed and efficient, and can meet the normal needs of users.

REFERENCES

[1] Chuan Xiao. Exploring the Reasons for the Rapid Development of Tennis in China[J]. Thinking Times, 2019(05):243-244.

[2] Li-shan Zhang, Yu-feng Yuan. Research on the Formation and Development of Chinese Tennis Culture[J]. Sports Excellence, 2018, 37(12): 46-47.

[3] Xiang-nan Fu. Research on dynamic modeling and control of omnidirectional mobile robot [D]. Shenyang University of Technology, 2018.

[4] Yuan-zhen Su, Lei Ji, Jia-xin Nie, Guo-jiang Wei, Yu-qin Guan. Design of Path Recognition Intelligent Car Based on STM32F407[J]. Information & Communications, 2017(08):31-33.

[5] Zhen-jun Cao, Jun-feng Jing, Ze-bin Su, Slow Zhang. Research on the depth detection of color fabric based on raspberry pie[J]. Cotton Textile Technology, 2019, 47(01): 11-15.

[6] Hao You, Xin-xin Zhang, Zhao-hui Zhang. Motion detection based on OpenCV and Raspberry Pi[J]. Electronic Technology, 2017, 46(02): 59-61.

[7] Ya-wen Li, Jie Zhao, Xin Zhang. Study on Moving Target Tracking Algorithm Based on CamShift in Surveillance Video[J]. Ship Electronic Engineering,2018,38(09):27-30.

[8] Shu-jing Zhang. Research on target tracking method of mobile robot based on Camshift algorithm [D]. Beijing University of Civil Engineering and Architecture, 2018.

[9] Si-yu Lin. Research on Fatigue Driving System Based on OpenCV[A]. Advanced Science and Industry Research Center.Proceedings of 2017 2nd International Conference on Computer, Mechatronics and Electronic Engineering(CMEE 2017)[C].Advanced Science and Industry Research Center:Science and Engineering Research Center,2017:5.

[10] Ru Li, Jing-wen Hu. CamShift algorithm and embedded target tracking system[J].Wireless Interconnect Technology,2018,15(18):76-77.