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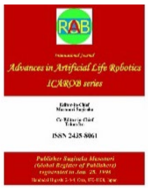

Research Article

Design a Mobile Robot with Image Recognition Function based on LabVIEW and KNRm

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ABSTRACT

The main purpose of this paper is to use the image recognition function of LabVIEW to construct a mobile robot with various functions, and make it applicable to the industry having web monitoring applications. The core of the robot is the KNRm controller which is suitable for beginners, and can be connected to DC servo motor, RC servo motor, infrared, ultrasonic and camera to achieve various functions of the robot. The structure of the robot uses metal parts sold by Studica company, which can be in accordance with the desired function to assemble the robot. Since the company is a designated equipment sponsor company for World Skills competitions, it can also be in line with international standards. Finally, PID control and sensors are added to make the robot movement and position more accurately.

1. Introduction

With the increasing advancement of science and technology, the products of robots are becoming more and more diversified, especially in terms of mobile robots. Mobile robots are generally closely related to people's lives, such as sweeping robots and robots used in hotels and restaurants. Many countries are focused on the robot industry. And the growth of mobile robots will be faster than industrial robots. Since the outbreak of COVID-19, many countries have implemented lockdowns to prevent the spread of the virus. At this time, mobile robots appropriately play the role of logistics, accompaniment, and transportation of people's livelihood or medical supplies [1], [2]. The design and development of mobile robots has also received increasing attention in the field of education and competition [3], [4], [5]. Taking the high school industrial student skills competition held by the Ministry of Education in Taiwan, which is the most important high school competition in Taiwan, as an example, the number of participants has been grown from 86 to 102 in 3 years [6]. Compared with the annual decrease of about 10,000 students in these three age groups in Taiwan, this contrarian growth shows the vigorous development of robot education in Taiwan.

2. Problem Description

This paper takes the test project of the 49th National Skills Competition in Taiwan as the subject of problem solving. The competitors are asked to design a toy organizing robot. This robot can help the children put the toys into categories after the game. The layout of the competition field is shown in Figure 1. Zone A in Figure 1 is the starting area of the robot, and the size of the robot

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must be completely within the range of the starting area. There is a height-limit gate on the passage as shown in Figure 1 marked as G, and the robot must be below this height to pass the gate. Zone B is the golf ball sprinkling area. Before the start of the evaluation, 5 to 6 golf balls of 5 colors are sprinkled via the sprinkler, as shown in Figure 2, to Zone B. Zone C is the target ball-collection area. There are five slots in Zone C. A barcode is hanged on the wall of each grid to indicate balls of what color should be placed in the grid. At the beginning, the robot starts from the starting area, and firstly reads the barcode of each grid in Zone C, and then passes through the passage and gate to the golf sprinkling area to pick up the golf ball. After gripping, the robot returns to the ball-collection area and places the balls according to the color assigned by the barcode. The robot must collect the balls as much as possible and place them to the correct slots within the limited time duration, and return to the departure area before the end of the time. Similar to the prototype development process of general robot product design, competitors should use appropriate metal building blocks and self-designed 3D printed parts, if necessarily, to construct a robot that meets the functional

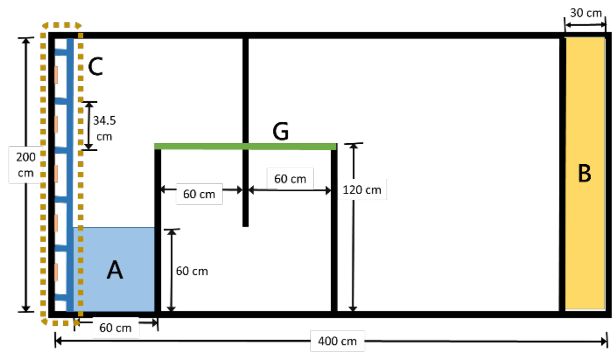

Fig. 1. Field of the considered problem.

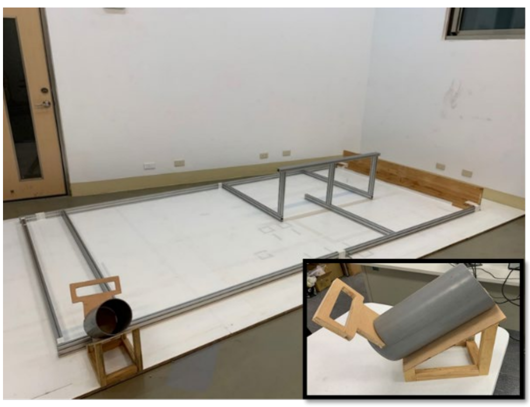

Fig. 2. The field with the sprinkler.

requirements of the test project. In order to test the design of the robot mechanism under limited resources, the number of motors and sensors are limited as mentioned in the test project.

3. Hardware Design

We mainly use integrated kits, including Tetrix metal blocks, sensors and motors packaged by Studica, to design and assemble robots according to assigned functions. The controller adopts KNRm Figure 3 developed by KKITC, and its main core is NI myRIO-1950. The main difference between KNRm and myRIO is: A single myRIO requires the user to connect the I/Os, or the user have to make a suitable expansion board to connect the useful pins. But KNRm has a built-in expansion board. Users do not need to develop expansion board by themselves, as long as they can directly connect to the motor, sensor and camera according to their needs. Most of the pins that need to be used in KNRm are designed around the controller, which is convenient for users to use. Like myRIO, KNRm can also be programmed using LabVIEW developed by National Instruments (NI). Unlike traditional programming languages, LabVIEW uses the G language and uses a graphical user interface, so that new users can quickly understand how to write LabVIEW programs. LabVIEW's data flow design method allows users to program according to the required functions during conceptualization. In addition, G language has parallel processing capabilities [7]. In terms of mechanism design, because the golf balls have to be gripped out from the sprinkling area, a lifting mechanism and a ball clamping mechanism are necessary. In addition, the picked golf balls need to be stored on the robot. Hence a ball storage mechanism is required. There are only 2 ports for RC servo on KNRm controller. However, to meet the above requirements, 3 RC motors are necessary. So we use an RC expansion box to solve this problem. Due to the use of the RC expansion box will occupy one DC motor-port and there are only 4 motor-ports in a KNRm, only 3 DC motors can be used for the chasis motion. Hence we choose to use the triangular chasis with 3 omni wheels. With omni wheels, it can achieve the functions of forward, backward, left and right motion, rotation and diagonal movement of the chassis.

The analysis about the robot body design is as following.

1. The ball clamping mechanism: Since the golf balls have to be moved to the collection area in a limited time, the design of the clamp mechanism is to clamp as many golf balls as possible. However, the blocks provided by Studica are not suitable for use. We design a customized part by 3D printing.
2. The ball storage mechanism: Due to the need of storing multiple golf balls on the robot without increasing the number of RC motors, a ramp with end-block is designed to allow the balls to roll into for storage.
3. The lifting mechanism: In order for the balls rolling smoothly into the ball storage mechanism, it is necessary to raise the clamp mechanism to a certain height. In addition, beside the lifting mechanism, a mechanism that can move back and forth must also be connected.

Finally, in addition to the above analysis, it must also meet the conditions of the test project that the robot must not exceed the starting area when starting, and then the robot cannot be allowed to hit the height limit gate when passing through it. These two conditions must also be taken into consideration when designing the organization. The overall design of the mechanism of the robot is shown in Figure 4.

Fig. 3. KNRm controller

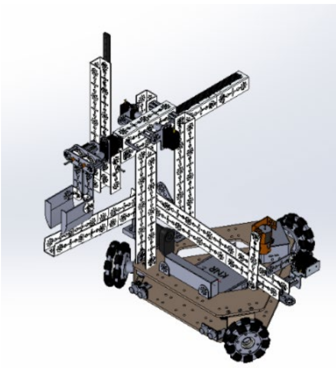

Fig. 4. The mechanism of the designed robot.

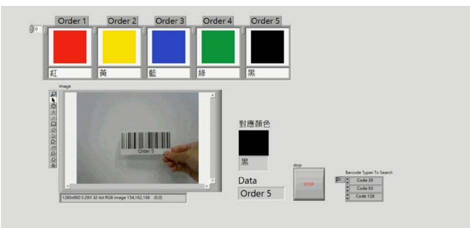

Fig. 5.1. Barcode reading and color determination

For obstacle avoidance, we use ultrasonic sensors as the main sensor, and infrared sensors as an auxiliary. The reason is to improve the accuracy of travel and overcome the lack of infrared rays that can pass directly through when encountering certain obstacles. The advantage of ultrasound is that the distance is farther than infrared. The ultrasonic sensor used in this paper is PING))), and the infrared sensor used is SHARP GP2Y0A21YK0F.

In the motion control part of the robot, we use trapezoidal acceleration and deceleration and PID control for control to make the robot's movement more precise.

4. Image Recognition

In the problem to be solved in this article, it is necessary to read the barcode and color judgment, as shown in Figure 5.1. Therefore, we use Logitech C310 camera as the image sensing device. In LabVIEW, users can combine their own image processing programs with built-in VIs, or use LabVIEW's visual assistant function to achieve quick start-up processing. Vision Assistant is an integrated program for LabVIEW image processing, with many image processing functions. The Vision Acquisition program can be used to set up the camera, including the acquisition source, acquisition type, camera resolution and frame number, etc., and then use the Vision Assistant to process the images acquired by the camera. In the visual assistant, you can set and process the options of image, color, grayscale, binary, machine vision, recognition and other items. Since the images processed in this article are mainly for the interpretation and recognition of bar codes and golf balls, we only deal with these two parts in image processing. The identification of golf balls is mainly carried out by methods such as binary, grayscale, color, and Hough rounding. And for the bar code interpretation, a built-in function of LabVIEW is used. It can be completed by adjusting the corresponding barcode model, so we directly use Find Circular Edge and color comparison instead of image technology to perform grayscale processing on the paper.

5. Experimental Results

We conducted field test with the robots we designed. After the robot leaves the starting area, it reads the barcodes first, as shown in Figure 5.2, and stores the color specified for each ball slot. After that, the height of the robot must be lowered so that it can pass through the gates in the passage smoothly. After the robot has completely passed the passage, it uses ultrasonic and infrared sensors to correct the robot's posture based on the side wall, and turns to make the gripper face to the golf sprinkling area, and then goes to the sprinkling area. In order to facilitate the gripping of golf balls scattered in the sprinkling area, the robot will sweep the balls into the same area after reaching the sprinkling area, and then perform the action of gripping the balls. After many tests, it was found that the gripper designed by 3D printing could only clamp two balls at a time, so it was necessary to repeat the clamping action several times to make it possible to clamp more balls. After performing multiple clamping, the robot then returns according to the path it came. When passing through the gate, the clamping mechanism should be lowered to pass it. After passing through the gates, the gripper returns to the original position, and place the golf ball in the corresponding grid when the robot passes through each collection area. Finally, after releasing all the balls, the robot returns to the starting area to complete the experiment. After actual testing, the robot we designed can be successfully used to achieve the tasks required by the problem and return to the starting area, as shown in Figure 6.

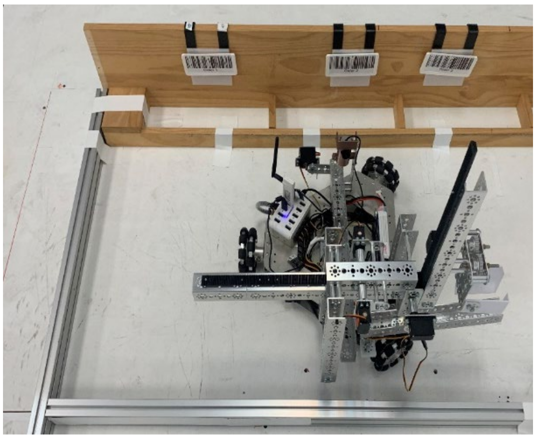

Fig. 5.2. The robot starts and reads the barcodes.

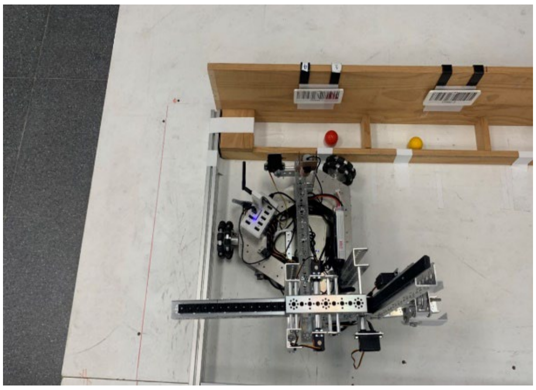

Fig. 6. Task completed.

6. Discussions and Conclusions

In this paper, a KNRm is used as the core controller of the robot, combined with the Tetrix metal building blocks, three motors, three RC servo motors and appropriate sensing devices, to design a solution that can solve the project of Mobile Robotics of 49th National Skills Competition in Taiwan. The designed robot has been verified on the field and found that it can indeed achieve the specified task.

Because it is composed of metal building blocks, the designed robot will be insufficient in terms of mechanical rigidity. When designing robots to solve other application problems, metal building blocks similar to this paper can also be used to design the prototype of the robot to test whether the function can meet the requirements or not. When the designed robot can meet the requirements, one can proceed with the appearance design of the robot to be used as a commercial product. At the same time, the mechanical rigidity of the robot is included in the material consideration. This can greatly reduce the time for product development, and can more accurately demand for application products.

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