Intelligent Handling Robot Based on Mecanum Wheel

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Abstract. This paper proposes an intelligent handling robot based on Mecanum wheel, which can be set to recognize and handle the goods in the inherently known site, and can be adapted to the logistics sorting and other scenarios. The robot to NXP's RT1064 microcontroller as the main control, the use of RT-Thread embedded system development, the Mecanum wheel as a framework, the independent construction of the car model structure, equipped with a Raspberry Pi and robotic arm structure, as well as the MT9V032 total drilling wind camera to build the hardware circuit. The robot can recognize the position of the handling object through the off-site camera, then the upper computer for path planning, through the PID parameter adjustment and vehicle attitude solving to control the movement of the handling robot, to reach the handling location and then by the total drilling wind camera for detailed position adjustment. The robot equipped with Openart mini can recognize the type of objects to be handled, pick them up and place them on the pallet through robotic arm attitude solving, and correct the deviation through remote manual control, and finally realize fast omni-directional handling through Mecanum wheels to deliver the objects to the end point.

Keywords: Mecanum Wheel; Automated Handling; Machine Vision; Deep Learning; Remote Manual Control.

1. Introduction

With the development of science and technology, intelligent control, neural network applications are becoming more and more widespread, how to promote the mechanical, electronic and other traditional industries to the deep development and landing application has become the current research hotspot. The rise of the logistics industry has also led to the emergence and development of logistics robots.

Existing logistics robots can efficiently complete the handling tasks but does not have the function of identification and classification, still need to be classified as valuables and ordinary items, not completely liberate human productivity. In addition, this type of robot does not have the function of remote monitoring and maneuvering, and it is impossible to manipulate the robot to deal with some unexpected problems. Based on these two defects, this paper proposes a new type of intelligent handling robot.

The intelligent handling robot is able to realize the identification and handling of goods in the inherently known site, and can be adapted to logistics sorting and other scenarios, which greatly improves the production efficiency and liberates productivity; in addition to this, the robot can also be remotely manipulated by artificial remote control and road exploration in unknown or unexpected situations to minimize the risk of loss, and can also be operated manually to achieve the intrinsic function outside the function. In addition, robots can also be operated manually to realize functions other than the inherent ones [1].

2. Intelligent Robot Design

The overall structure of the intelligent robot is shown in Fig. 1. It includes the motherboards, robot arm, Locomotive, camera, motor, motor drive circuit, encoder, batteries, and power circuit [2].

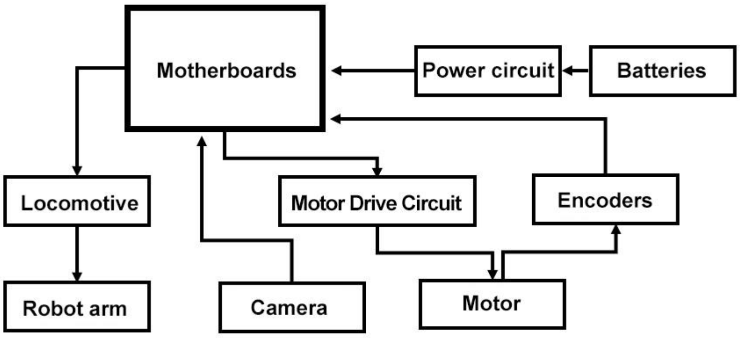

Fig. 1 Overall Block Diagram

2.1. Power Circuit Design

The robot uses an 11.1V Li-polymer battery as the main power supply, and a three-stage step-down circuit is designed to power different peripherals. 6V is used to power the servo, 3.3V is used as the operating voltage for the microcontroller, and 5V is used to power the encoder. In addition, a voltage regulator circuit is designed to stabilize the power supply. The schematic diagram of the 6V voltage regulator circuit is shown in Fig. 2.

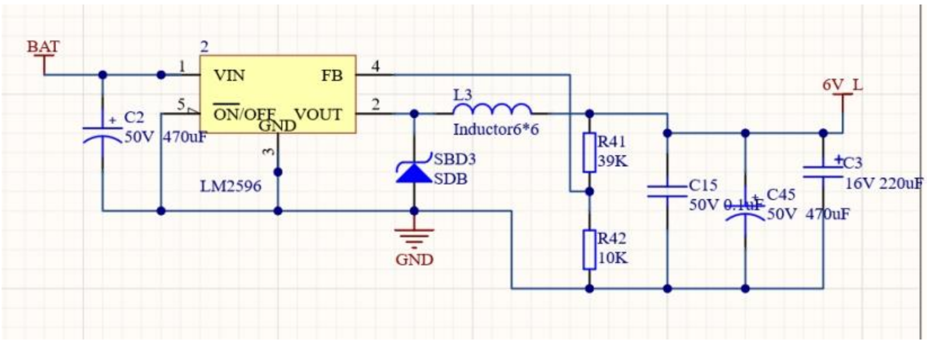

Fig. 2 6V Regulator Schematic Diagram

2.2. Motor Drive Circuit Design

Robot motor driver chip selected BTN7971B driver chip, which has logic level input, current detection and diagnosis, voltage swing rate adjustment, dead time generation and over-temperature, over-voltage, under-voltage, over-current and short-circuit protection, etc., which is convenient for control and circuit design.

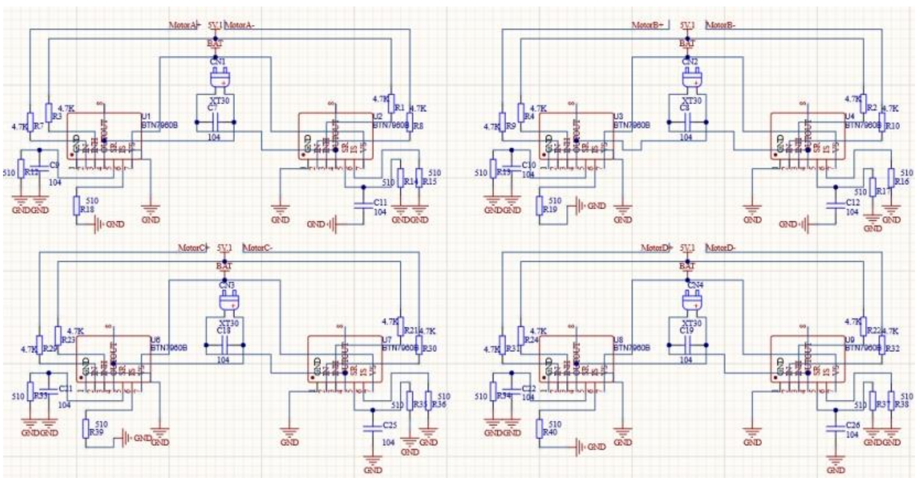

Fig. 3 Motor drive schematic diagram

In order to better drive the motors inside the robot and control the robot to move in practice, we finally refer to the H-bridge motor drive circuit and design and realize a new type of drive circuit. Specific motor drive schematic shown in Fig. 3.

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3. Intelligent Robotics Software Design

3.1. Camera coordinate extraction and path planning design

In the case of known need to carry the coordinates of the target, we need to identify the coordinates of the paper to obtain the target of the target, at the same time, in order to facilitate the code has been to the lower computer we cannot call any image processing library function, so we use the seed region growth algorithm to achieve the traversal of the image. That is, set an initial seed, the use of the stack, all the black areas added to the stack area, and finally the conditions of these areas can be screened to get the ideal screening results, of course, in order to obtain the precise coordinates, enhance robustness, we also need to carry out the image of the perspective transformation. The target location is shown in Fig. 4.

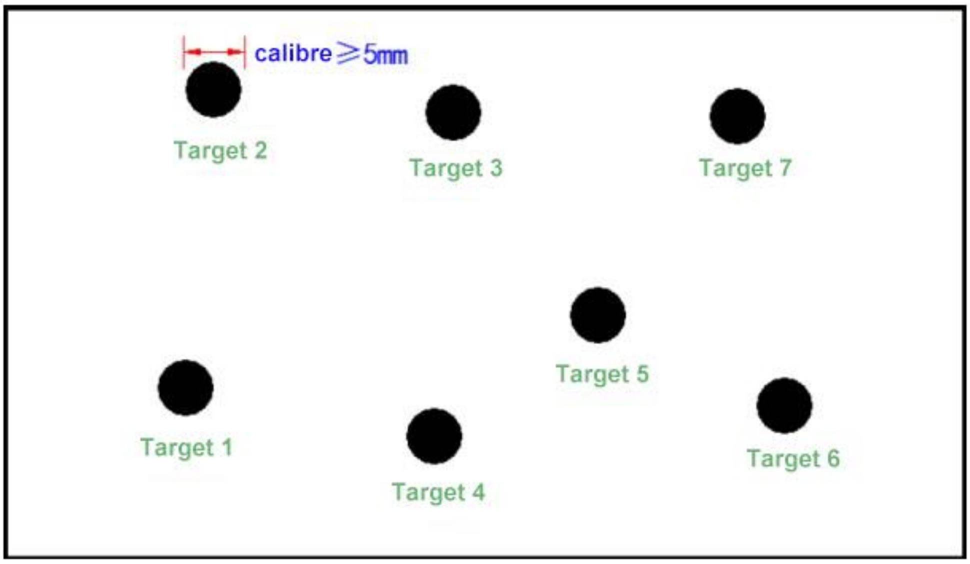


Fig. 4 Map of Known Target Location

After the processing, we need to plan a path that is most suitable for the movement of the robot, so we use an optimization algorithm to carry out the path planning process. In order to get better results, we compared the annealing algorithm with the genetic algorithm, and finally chose the genetic algorithm to solve the problem.

3.2. Off-site camera applications

In order to cope with the situation of positional coordinate points, it is planned to use off-site cameras to obtain the information of site coordinate points and calculate the accurate coordinate information. The specific scene is shown in Fig. 5.

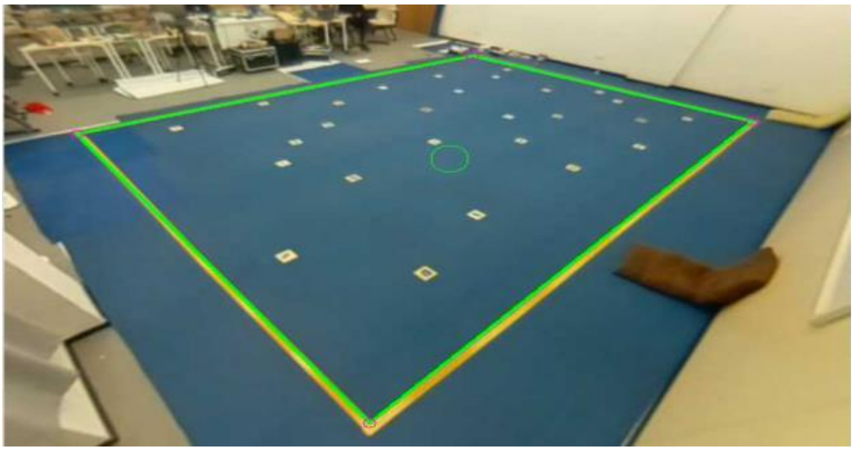
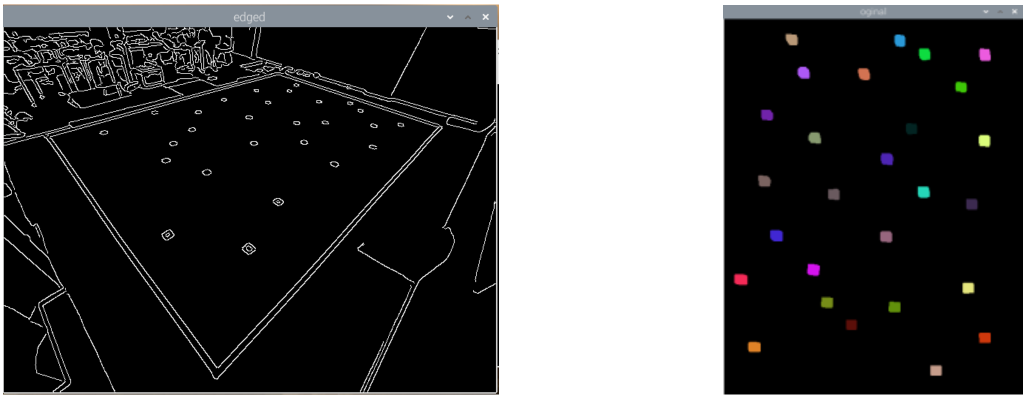


Fig. 5 Actual Test Scenario Diagram

The robot uses a Raspberry Pi as the processing tool for the off-site camera and OpenCV to realize the target task. In order to be able to capture the entire field, we chose a wide-angle camera with distortion correction, which allows the camera to obtain a larger field of view at a lower height [3]. We use Canny operator edge detection and connect domain screening to frame the target area; in order to solve the problem of uneven light distribution, we adopt the local Otsu thresholding method to perform image binarization within the target area, and then further connectivity screening within the target area to find the target, and finally get more accurate coordinates through perspective transformation. As shown in Fig. 6(a) for the actual construction of the scene edge detection results; Fig. 6(b) for the perspective transformation after the extraction of the actual coordinates schematic, through the real test, the method of target coordinate recognition and extraction of the correct rate can be close to 100% [4].



(a) Edge Detection Results (b) Extraction of Coordinates

Fig. 6 Schematic Diagram of Coordinate Information

3.3. Model preprocessing and training

In order to improve the accuracy and robustness of the recognition, we need to expand and process the dataset to generate various types of images to simulate the environment with high or low light intensity, in addition to expanding the angle of the dataset, so as to be able to recognize the images with various angles. The original dataset has only one direction and has a lot of differences with the actual pictures taken, the actual pictures may have rotations, blue edges, overexposure, overdarkness, reflections, blurring, etc. Therefore, we need to augment the original images with data, and the ways of augmentation include taking pictures, rotating the large corners, rotating the small corners, blurring, brightening, darkening, etc. The original dataset has about 3,000 pictures, and the augmented dataset has about 120,000 pictures. Some of the most enhanced images are shown in Fig. 7.

Fig. 7 Data Enhancement Renderings

After importing the dataset, set the input graph size at the beginning of training as 128*128*3, learning rate 0.01, Batchsize as 64, and then choose 0.001 learning rate and 32 Batchsize after the loss is stabilized, and finally choose 0.0001 learning rate and 16 Batchsize until the end of training. After the end of training and then verify the accuracy of the model, the model can be converted and exported after the verification is correct. The specific model training results are shown in Fig. 8.

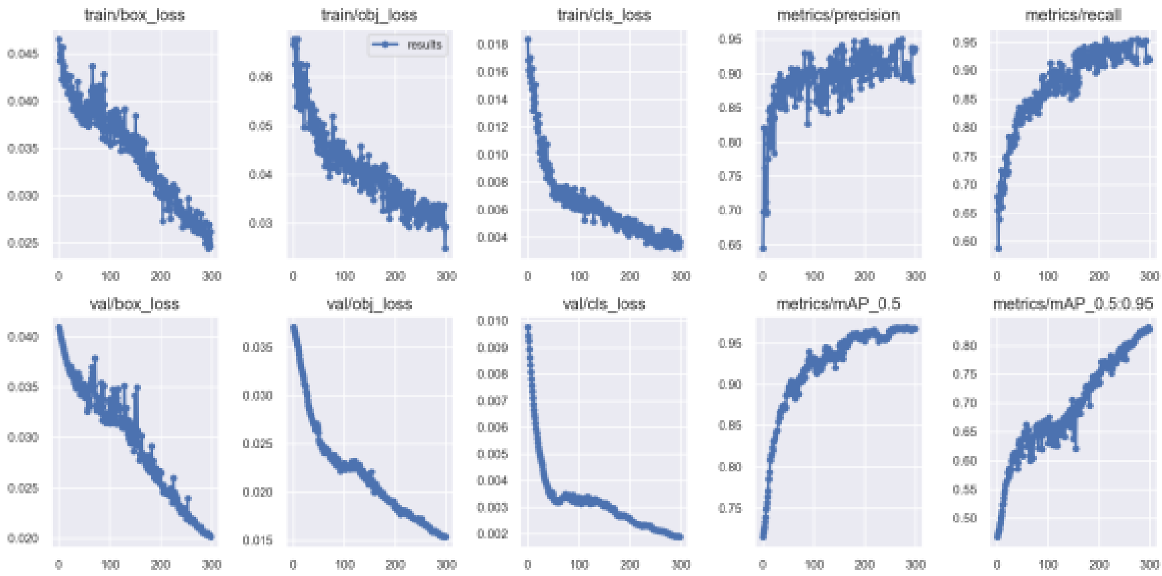


Fig. 8 Model training results

From the above figure, it can be seen that the actual model training has a better recognition effect, and the recognized mAP value can finally reach 99.5% of the mAP value with the intersection and merger ratio of 0.5, and 97.2% of the mAP value with the intersection and merger ratio of [0.5:0.95].

3.4. Mecanum wheel control algorithm design

As the Mecanum wheel has two kinds of A and B wheels in mirror image relationship with each other inside, i.e., the left-hand wheel and the right-hand wheel. The overall omni-directional movement can be accomplished by adjusting the velocity values of the two wheels in the x, y, and z directions, and in order to make the cart start and stop more smoothly, we also wrote PID control codes such as the velocity loop and position loop [5].

In order to obtain the current moving distance and coordinates, we need to utilize the encoder to calculate the distance moved by the cart. At the same time, in order to minimize the error, we also fixed the direction of the head of the cart, and the gyroscope is used to correct the attitude of the body in real time, in order to prevent the cart from being incorrectly oriented, which produces an error in the distance.

In order to better control the speed of the motor, we carried out PID closed-loop on the speed control of the motor, each wheel has its own separate PID, and also utilized the same PID for acceleration and deceleration and angle control, and we set the limit of the motor output at 40%, to prevent some unexpected situations from causing acceleration and deceleration to be too fast or the car to be out of control when meeting the speed requirements [6].

4. Overall Robot Performance Test

Based on the previously constructed scene on the robot performance of a series of tests, the results show that the handling robot automatically shifted to the distance of the target object error control within 5cm, the success rate of the automatic adjustment of the position of the object after the handling of the success rate of about 99.5%.

The accuracy of its built-in visual recognition system can reach about 92.4% in the indoor with good lighting conditions, and 65.9% in the general environment; the off-site camera recognizes the position of the goods with an error of 2% or less and realizes the success rate of robot arm handling of more than 90%.

5. Conclusion

The intelligent robot proposed in this paper, in addition to being able to fulfill the requirements of intelligent handling, also realizes remote network connection viewing and remote control, combines automatic and manual modes, broadens the uses and explores new applications of Mecanum wheels. From the test results, the intelligent handling robot based on Mecanum wheel has high accuracy and successful rate of handling. However, its environmental requirements are high, and the project's light robustness remains weak. Follow-up research will be devoted to optimizing the performance of the project and improving its robustness.

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