Smart Car Based on Open MV Vision System

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Abstract. Modern society is developing rapidly, social informationization, and the degree of science and technology has become higher and higher. The development of intelligence has gradually entered people's vision, and will eventually become a part of human life in the future. In order to facilitate people's use, a target tracking method based on Open MV vision system is proposed. The machine vision Open MV module is used to collect image information, and through image information processing, the information is transmitted to the central control chip STM32 core control board. And the various modules that control the car work together. The method can resist the interference of illumination changes, achieve path optimization to a certain extent, and achieve real-time processing under limited computing resources. At the same time, the design is simple and the cost is low. The experimental results have been obtained through experimental tests, and the follow-up of the trolley has been successfully realized. Later, it can be used as a reference for the design of the driverless car and can also be used for the design of the smart car toy.

1. Introduction
In recent years, with the rapid development of intelligent field, a wide range of research on intelligent vehicles has begun at home and abroad. As a miniature model of intelligent vehicle, intelligent car is an intelligent system that integrates behavior control and execution, dynamic path planning and decision-making, and environment perception. It uses image sensors to collect path information, transmit the acquired path image information to the processor for processing, control the intelligent vehicle for path recognition, and then binarize and denoise the image information, so as to simplify the visual navigation circuit, improve the real-time performance of the intelligent vehicle and simplify the algorithm. At present, intelligent car has become a compulsory course for beginners of single-chip computer. Smart cars can be seen in all kinds of robot competitions held by domestic and foreign organizations.

Smart cars have been widely used in many industries. Based on this, this paper uses Open MV machine vision module as image acquisition and processing platform [3], through the STM32 core control board to control the intelligent vehicle to achieve intelligent follow.

2. Grayscale of image
Gray image refers to the image that contains only brightness information but not color information. Its brightness can be divided into 256 gray levels (0-255 gray levels). The binary image can be obtained by threshold processing of gray image [4]. Grayscale image refers to the process of transforming color image into grayscale image after processing.
3. Image binarization

Binarization plays a very important role in digital image processing. Image binarization reduces the amount of image data greatly, so that the general outline of the target can be obtained clearly.

Image binarization usually uses threshold segmentation technology [5]. This technique is especially effective for images with strong contrast between object and background. If there are uniform and consistent gray values in the target area, and they are in a uniform background with another gray value, the threshold method can get a better effect; if the difference between object and background is not in the gray value, the property can be converted to the difference of gray level, and then the image can be segmented by the threshold technology.

Threshold selection has a vital impact on image binarization. Image binarization is based on reasonable threshold. By traversing the pixels of the source image to be processed, the number of pixels in the source image is calculated, and the gray value of each pixel is summed up, and the average gray value is calculated finally. Using the average gray level of the whole image as the threshold of binarization, the algorithm is simple, fast and easy to be executed by a single chip computer. This value can generally be used as the initial guess value.

4. Design Ideas

4.1. System Overall Scheme Design

The intelligent vehicle system uses STM32 core control board to control the speed, running and stopping of the intelligent vehicle. Open MV camera is used for image acquisition [6] and binary processing of image information. Convert the corresponding angle information and color block information into strings.

Through serial communication, the string is transmitted to the STM32 core control board, and different instructions are sent according to different angle information and color block information to realize the control of the driving steering gear module, motor module and other modules.

This greatly improves the stability of line-finding, and can easily deal with the interference of light and color noise similar to the site. At the same time, it can automatically change speed according to the curvature of the curve.

4.2. Open MV Features of Machine Vision Module

Machine vision is a branch of AI which is developing rapidly. Simply put, machine vision is to use machines instead of human eyes to measure and judge. Machine vision system converts the captured object into image signal by machine vision image capturing device (CMOS and CCD) and transmits it to a special image processing system. According to the information of pixel distribution, brightness and color, it converts it into digital signal. The image processing system extracts the features of the target by various operations, and then according to the preset permissibility and its value. He conditionally outputs the results and realizes the automatic recognition function.

Open MV camera module is an open source, low cost, powerful CMOS image acquisition module, mainly used in the field of machine vision. Its OpenMV on-board ARM Cortex M7 processor integrates OV7725 camera chip with resolution up to 300,000 pixels. It realizes the core algorithm of machine vision efficiently with C language, and provides Python programming interface with high efficiency and low power consumption. It can easily realize common algorithms such as image enhancement, line detection, filtering and denoising, and can be controlled by UART, I2C, SPI and GPIO. Other hardware, these characteristics make it very flexible to cooperate with other modules, so as to achieve complex functions. It can be used in color tracking, two-dimensional code recognition, face detection and other scenarios [8].

4.3. Driver Design

Intelligent vehicle realizes PID control steering and motor differential control[9]. The road color area and trajectory are collected by Open MV machine vision module, and the image is divided into three
rectangles. In each rectangle, the designated color blocks are detected and a maximum area color block is found. The deflection angle is calculated by weighted average method according to the central position of the three color blocks, and then the deflection angle is calculated by weighted average method. Through serial communication to STM32 core control board, STM32 core control board processes these image information, outputs the corresponding signal to the driving module to drive the motor to rotate, realizes the real-time control of each control module, and then controls the movement of the entire smart car.

The drive of the intelligent vehicle is driven by the control chassis motor. The control chassis is a control system based on MCU and traditional PID control algorithm. It consists of differential motor, motor driver, MCU and power module. In the corresponding PID debugging of the control chassis, the corresponding distance data and the corresponding object offset optical flow data are extracted from the corresponding machine vision data. Then the corresponding weighted PID is calculated, and the final PID function returns an integer natural number between 0 and 60000. The corresponding natural number returned is the corresponding counting discriminant value assigned to the single chip PWM generator.

4.4. Realization of Recognition and Following Function
After acquiring image information, Open MV machine vision module needs a series of image processing to transmit relevant information to STM32 master board. In this process, image graying and binarization are needed.

To recognize and track the black guide line, image information is collected by Open MV machine vision module, and a threshold is set on this basis. For each line of image information matrix signal collected by OpenMV machine vision module, the size of each pixel is compared from left to right. If the pixel value is less than the threshold, it is judged to be white, that is, the white runway; otherwise, if the pixel value is greater than the threshold, it is judged to be black, that is, the black boundary guide line.

After finding the black guide line, we need to determine whether the guide line is a straight line. If it is, we should abandon the frame image, return to the previous step and take the next frame image. If not, we can calculate the deflection angle between the straight line and the smart car, convert it into the angle that the smart car should turn, and convert it into the corresponding string at the same time. The corresponding string is transmitted to the STM32 core control board through serial communication, so as to control the steering angle and finally realize the following function.

4.5. Weighted Average Method for Image Segmentation
The image is divided into three rectangles and the largest black color block is found in each rectangle. The deflection angle [12] is calculated by weighted average method according to the center position of the three color blocks.

If the QQVGA image size is 160x120, ROI divides the image into three rectangles:

\[ \text{ROI} = \{ (0, 100, 160, 20, 0.7), (0, 0.50, 160, 20, 0.3), (0, 0.00, 160, 20, 0.1) \} \]

ROI represents three sampling regions, \( x, y, w, h, \text{weight} \), represents the rectangle whose width and height of the upper left vertex \( x, y \) are \( w \) and \( h \) respectively, and weight is the weight of the current rectangle. The threshold of three rectangles should be adjusted according to the actual situation, and the rectangular weight nearest to the field of vision of the smart car should be the largest.

5. Test results and analysis
First put the smart car on the white runway, guide it with black tape, and then follow it. The runway is 4 meters by 4 square meters. The number of times a smart car leaves the alignment in a week, and the driving process is tested. The test results are shown in Table 1.
Table 1 Trace test table

| project frequency | Follow the completion time (s) | Number of times off the guide line during driving |
|-------------------|-------------------------------|-----------------------------------------------|
| 1                 | 45                            | 0                                             |
| 2                 | 48                            | 0                                             |
| 3                 | 42                            | 0                                             |

According to the test results, the following function of intelligent vehicle is basically realized. After the module test is passed, the following function, color block recognition function and color block tracking function of the whole machine are tested according to the system design requirements. The experimental results show that the system scheme design is beneficial to the realization and the overall function is good.

6. Conclusion
In this paper, the general design idea and image processing method of intelligent vehicle are briefly described. After module testing and whole machine testing, the system has high control accuracy, small measurement error, low cost, reliable operation, strong anti-interference ability, and can be widely used in teaching, intelligent toys and handling occasions, with good use value.

References
[1] Zhao Y Z, Wang H, Yin G C. Research on Mean Shift Algorithm[J]. Advanced Materials Research, 2013, 756-759:5.
[2] Dodge S, Weibel R, Lautenschütz, Anna-Katharina. Towards a taxonomy of movement patterns[J]. Information Visualization, 2008, 7(3-4):240-252.
[3] Hai-Nan H E, Mao-Sheng F U, Bin L. Multiple Motion Targets Tracking Algorithm Based on Temporal and Spatial Information[J]. Computer Engineering, 2009, 35(18):219-220.
[4] Peng-Wei L, Hui-Yuan W, Wei Q, et al. Video Target Tracking Based on Motion Compensation and MCMC Algorithm[J]. Computer Engineering, 2010, 36(11):185-187.
[5] Sun B, Huang S. Target detection and tracking under moving background[J]. Journal of Electronic Measurement & Instrument, 2011, 25(3):206-210.
[6] Ess A, Schindler K, Leibe B, et al. Object Detection and Tracking for Autonomous Navigation in Dynamic Environments[J]. The International Journal of Robotics Research, 2010, 29(14):1707-1725.
[7] Kong X. Motion object tracking algorithm using multi-cameras[C]// Spie Optical Engineering + Applications. International Society for Optics and Photonics, 2015.
[8] Fu Q X, Zhang J. Moving target detection based on motion filter and tracking point cohesion for through wall radar[C]// Cie International Conference on Radar. IEEE, 2017.
[9] Lv W, Feng Y, Zhao H F. The motion contour-based target detection and tracking[C]// International Conference on Visual Information Engineering. IET, 2008.
[10] Newstadt G E, Zelnio E, Gorham L, et al. Detection/Tracking of moving targets with synthetic aperture radars[J]. Proceedings of SPIE - The International Society for Optical Engineering, 2010, 7699.
[11] Cao H. The research on the mean shift algorithm for target tracking[J]. IOP Conference Series Earth and Environmental Science, 2017, 69.
[12] DU, Xian-yan, HAN, et al. Moving Target Tracking Based on LogGabor Wavelet and Mean-shift Algorithm[J]. Semiconductor Photonics & Technology, 2009, 15(2):81-85.