Control method of three-wheel intelligent tracking logistics car based on OpenMV4

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Abstract: The author designs an intelligent lifting transport device based on STM32 microcontroller. The lifting device is designed with STM32F407ZGT6 as the control core, and the hardware consists of OpenMV4 recognition, gray tracking, motor drive and other modules. It can carry out automatic, gray tracking, OpenMV4 recognition, intelligent material grasping and other functions, and can follow the track black line on the set plane track, and complete the preset operation. The experimental results are good.

1. Introduction
The sixth logistics technology (crane) creative competition of Chinese college students’ mechanical engineering innovation and creativity competition is one of the series of professional events organized by the Chinese Mechanical Engineering Society. Its purpose is to enhance the scientific and technological innovation consciousness of college students through the competition, encourage college students to actively participate in scientific and technological innovation and engineering practice activities, improve the practical ability of college students to design and manufacture crane according to actual needs, broaden the vision of scientific and technological innovation of college students, and improve the application consciousness of crane in various fields of national economy.

The design of intelligent material transportation device is based on the requirements of intelligent identification, accurate placement and automation of goods in this competition. Taking the reality of intelligent logistics transportation and the development of future logistics industry as the theme, this paper designs an intelligent material transportation device1-2 based on STM32 F407 ZGT6 single chip microcontroller. The device can realize material identification, independent positioning, tracking and other functions through the control of the main control program, so as to quickly and accurately realize the positioning and handling of the device.

2. Overall system programme
The system uses STM32F407ZGT6 single chip microcomputer as the main control board, and uses gray tracking to move in the pickup area after startup. At the same time, OpenMV4 camera is used to identify the QR code that is arranged in advance next to the goods in the site. When the QR code is identified, the goods are classified in the program according to the recognition results. At the same time, the position of the device is fine-tuned to complete the positioning of the device. After positioning is completed, the goods are picked up and stacked at different positions on the car body.
according to the category of the goods; after picking up all the goods, the gray sensor is used to process the trail to the stacking area according to the specified route, and the QR code of the three stacking areas is identified again. After the identification is completed, the corresponding categories of goods are stacked in the stacking area.

3. hardware circuit design

STM32F407ZGT6 single chip microcomputer is the main component of the system, the main function is to control the running process of the tracking and motor drive module, so that the car can follow the track on the specific flat track. The OpenMV4 recognition module visually processes the QR code on the ground, and transmits the information to the single chip microcomputer to assist the clamping and stacking stage of the fixture.

3.1. Motor drive module

Since the shape of the device is triangular, the wheel part of the device uses the triangular arrangement of omni-directional wheels. The axis of the three wheels is 120°, and the center of the omni-directional wheel is distributed on the same circle. The axis of the wheel points to the center of the platform. The
simplified kinematic mathematical model is shown in Fig. 1. \( V_1, V_2 \) and \( V_3 \) are the rotational speeds of the three wheels, \( \omega \) is the rotational angular velocity of the platform as a whole, \( V_x \) and \( V_y \) are the macroscopic moving speeds of the platform relative to the world coordinate system, \( L \) is the vertical projection distance from the center of the platform to the center of the wheel, \( \theta \) is the angle between the wheel shaft and the \( x \) axis, and \( \theta = \pi / 6 \) is not difficult to obtain from the installation angle of the wheel \( 120^\circ \). Then the speed conversion matrix of each wheel is:

\[
\begin{bmatrix}
V_1 \\
V_2 \\
V_3
\end{bmatrix} =
\begin{bmatrix}
-\frac{1}{2}
& \frac{\sqrt{3}}{2}
& \frac{\pi}{6} \\
\frac{\pi}{6} \\
\frac{\pi}{6}
\end{bmatrix}
\begin{bmatrix}
L \\
V_x \\
V_y
\end{bmatrix}
\]

The expressions of \( V_1, V_2 \) and \( V_3 \) can be obtained:

\[
\begin{align*}
V_1 &= -\frac{1}{2} V_x + \frac{\sqrt{3}}{2} V_y + L \omega \\
V_2 &= -\frac{1}{2} V_x - \frac{\sqrt{3}}{2} V_y + L \omega \\
V_3 &= V_x + L \omega
\end{align*}
\]

For each individual wheel, the 'S' acceleration and deceleration control algorithm is used to control the acceleration and deceleration of the wheel. As shown in Fig. 3, the 'S-shaped' acceleration and deceleration control algorithm is a better control strategy for flexible programs, which is relatively slow at the beginning of acceleration / deceleration and then gradually accelerates. When the acceleration / deceleration is close to the end, the speed is slowed down again, which can make the motor performance fully play and the impact vibration is small, so it can make the movement of the car body more gentle.

At the same time, due to the different friction forces on the ground of the wheels in different
directions on the car body, there is a certain gap in the speed of the wheels in different directions when the same current value is output, resulting in the inaccurate motion of the car body. In order to eliminate these errors, the PID algorithm is added in the program. Through the speed value and position value feedback by DC motor, the two-loop PID control of speed loop and position loop is formed. Through this PID control method, the device can accurately control its movement.

In the clamping part, three electric push rods and two micro push rods are used to realize the upper and lower movement of the cantilever and the clamping and opening of the fixture. At the same time, a 57 step motor and a 42 step motor are used to control the selection of the cantilever and the movement of the fixture on the cantilever. For these two stepper motors, the step angle is 1.8°. In the case of directly connected pulse signals, each pulse can control the rotation of the motor shaft by 1.8°, and 200 pulses can make the motor shaft complete circular motion. In this project, a special stepper motor driver is used to control the stepper motor. This driver supports 128 subdivisions at most, so that the rotation can be controlled more subtle.

3.2. OpenMV4 identification module
OpenMV is an open source, low cost, powerful machine vision module[4]. With STM32F427 CPU as the core, the OV7725 camera chip is integrated. On the compact hardware module, the core machine vision algorithm is efficiently realized with C language, and Python programming interface is provided. In this paper, OpenMV4 H7 camera is used to realize the two-dimensional code recognition function. Firstly, Python language is used to study the target recognition and tracking algorithm. The images collected by the camera are preprocessed using the algorithms of image filtering, binarization, expansion and corrosion. Then the QR code reading function in the openmv library is used to read the information contained in the pre-arranged QR code in the field, and the obtained information is transmitted to the main control board through the serial communication. At the same time, an additional serial port is set to realize the main control board to control the opening and closing of OpenMV.

3.3. Grayscale tracking module
The gray-scale sensor used in this paper is similar to the infrared sensor, but it has its own characteristics. It uses high-bright concentrated LED light, and the receiving tube compares the strength of different reflected light. As long as the light reflection strength is different, it can be identified. It has a good recognition effect on the green and white or black and white ground commonly used for patrolling. For it, the larger the color difference, the better the resolution. Its output digital quantity is also called the switch quantity signal, is take the high and low level output as a signal sensor ; signal without AD conversion and without complex algorithms to achieve signal acquisition and control is one of its highlights and advantages. Then the main control board receives the signal value through the serial port for subsequent control.

The device feedbacks the signal value through two gray sensors arranged before and after the axis of the car body. In addition to the PID algorithm of the wheel part, a ring PID algorithm is formed to combine with it, so that the car body will never deviate too much from the preset trajectory. Therefore, through the operation of the module, the car can accurately and smoothly reach the specified position to grab the material.

4. Conclusion
In this paper, through the design of STM32 single chip microcomputer control intelligent material transportation device, the automatic material identification, autonomous positioning, tracking and other functions of the device are realized, and the competition task is completed according to the corresponding competition rules.
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