Design of intelligent throwing robot based on machine vision

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Abstract: An intelligent robot system integrating motion, machine vision and throwing function is designed. The system uses STM32 as the main control chip, realizes the motion control of the robot through mcnaum wheel, completes the image acquisition, recognition and processing of the robot with openmv machine vision module, and realizes the throwing function control of the robot through steering gear and motor. The intelligent throwing robot can recognize and grasp the ball of the corresponding color according to the functional requirements, move to the throwing area of the specified color, and complete the fixed-point throwing of the ball. Through the experimental debugging, the results of the intelligent throwing robot based on the design meet the expected requirements.

1. Introduction
With the rapid development of robot technology and the coming of information age, the application fields of robot technology are more and more extensive. This design takes the university level scientific research project platform as an opportunity to study the intelligent throwing robot based on machine vision. The following will start from the color recognition, grasping, throwing and motion control of the robot, combine the hardware structure design and program algorithm debugging to complete the design of the intelligent throwing robot based on machine vision.

2. Structural design of grasping and throwing part
According to the functional requirements of the intelligent throwing robot, the most important part of its structure design is the ball catching part and ejection part. In order to ensure the accuracy and stability of the ball catching and throwing parts, the structural design of the throwing part and the grasping part is particularly critical. Combined with the functional requirements of the intelligent throwing robot, the structure modeling design is carried out through UG, and the throwing and grasping parts of the structure are made with 3D printing technology. According to the performance requirements of the intelligent throwing robot, the stability of throwing and the flexibility of movement are guaranteed to the greatest extent. The selection of printing materials should be considered from the strength and weight of materials. Most of the materials on the market can meet the performance requirements. This design uses PLA plastic material. The strength and weight of the material meet the requirements of grasping and throwing, and the structural strength of the finished product after printing good and durable, can normally complete the throwing function and meet the performance requirements.

The grabbing part is composed of gear controlled closed claws. Because the grabbing ball is light and easy to slide, the full surrounding grabbing method is adopted to reduce the drop of the ball caused...
by shaking in the grabbing process and improve the success rate of grabbing the ball. The ejection part is controlled by a reduction motor and connected with a U-shaped tube. When the grabbing ball is successful, the grabbing ball is put into the U-shaped tube through the steering gear in the conduit, the small ball is thrown out by adjusting the deceleration motor to generate a certain torque. By adjusting the motor to change the torque, the throwing distance can be adjusted to ensure the accuracy of throwing. The main view and left view of the specific structure design are shown in Figure 1 and Figure 2.

![Main view of intelligent throwing robot based on machine vision](image1)

![Left view of intelligent throwing robot based on machine vision](image2)

### 3. Color ball recognition and position recognition strategy based on openmv

The accuracy of intelligent throwing robot for grasping and throwing chromosphere comes from the performance of machine vision modules such as openmv. Openmv sensor is an image sensor with certain machine vision functions. Combined with its built-in algorithm, it can complete color recognition, color block tracking, face recognition, code scanning recognition, edge detection, sign tracking and other functions. The program flow of target ball recognition, position recognition and throwing control of the throwing robot is shown in Figure 3.
3.1. Target recognition and capture
The intelligent throwing robot will be based on the color recognition algorithm, take the colored ball as the grab target, and set the color of the grab ball (assuming the red ball is selected). After the smart throwing robot starts to work, it controls OPENMV to first capture the image signal directly in front of the robot, to determine whether there is a target color ball in the image, and if it does not exist, control it to rotate 45° to the right and re-capture the image and scan it. If it has not been detected, return to the position before rotation and continue to rotate 45° to the left, capture the image again and scan again, according to this strategy combined with the pre-set robot motion path until the red ball signal is scanned in the captured image. Then analyze the coordinates of the captured image, extract the coordinate data of the red ball in the captured image, and pass it to the control chip. The control chip analyzes and judges the position of the red ball based on the coordinate data of the center of the small ball area. And control the intelligent throwing robot to move to a suitable position where the robot arm can grab the red ball. When it reaches this position, it immediately stops moving, and adjusts the OPENMV to control the robot arm and claws to grab the red ball.
3.2. Color recognition strategy of chromosphere
The intelligent throwing robot's recognition of the color of the target ball is mainly based on the collection of the LAB threshold in the LAB color model. First, the LAB threshold data of the target ball is collected through the OPENMV IDE threshold editor as shown in Figure 4, and then the program control of the color recognition of the target ball is completed through the Python programming code. The specific color recognition procedure of the target ball is as follows.

```python
def color_choose():
    while (True):
        img = sensor.snapshot().lens_corr(strength = 1.8, zoom = 0.8)
        if uart.any():
            a = uart.readchar()
            b = chr(a)
            if b == 'A':
                ball_color = Red_threshold
                return ball_color
            elif b == 'B':
                ball_color = Blue_threshold
                return ball_color
```

3.3. Location recognition and fixed-point throwing of target area
After the intelligent throwing robot successfully grabs the target color ball, according to the program design process, combined with the previous openmv image grabbing and scanning strategy, it continues to find the throwing area of the target (the throwing area is marked by different colors), finds the corresponding color throwing area, and extracts the center coordinates of the throwing area. Then the intelligent throwing robot is controlled to move to the coordinate designated position. After adjustment, the throwing action of the red ball is completed relying on the throwing structure. The specific target position control procedure is as follows.

```python
if blobs:
    check_count = 0
    max_blobs = find_max(blobs)
    img.draw_rectangle(max_blobs.rect())
    img.draw_cross(max_blobs.cx(), max_blobs.cy())
```
cx = str(int((img.width()/2) - max_blobs.cx()))
cy = str(int(max_blobs.cy() - (img.height()/2)) + 34)
if (int(cx)>(-8) and int(cx)<20 and int(cy)>(-6) and int(cy)<4):
    Servo_Right()
catch_flag = 1
cx = str(0)
cy = str(0)
flag = 'F'

4. The design of motion strategy based on mcnam wheel
In order to ensure the accurate and flexible motion of the intelligent throwing robot, four mcnaum wheels are used as the mobile mechanism of the intelligent throwing robot. Mcnaum wheels have omni-directional motion mode and flexible control. Through the two velocity components of mcnaum wheels in the motion process, the fast motion between specific coordinates can be completed. The position coordinates of the intelligent throwing robot are transmitted to the control chip by the openmv vision module. After data analysis, the control chip controls the forward and reverse rotation of four mcnaum wheels respectively. In order to ensure the accuracy of intelligent throwing robot motion, PD algorithm will be used for control adjustment. The specific procedures are as follows.

    Rol=sqrt(pow(x_axes,2)+pow(y_axes,2));
    Tri_Angle=atan(abs(y_axes)/abs(x_axes))*(180/Pi);
    PID_Init(Rol);
    Incremental_PD(&Encoder1_Data,Encoder_Data[0]);
    Incremental_PD(&Encoder2_Data,Encoder_Data[1]);
    Incremental_PD(&Encoder3_Data,Encoder_Data[2]);
    Incremental_PD(&Encoder4_Data,Encoder_Data[3]);
    Vm[0]=Encoder1_Data.PWM_Return;
    Vm[1]=Encoder2_Data.PWM_Return;
    Vm[2]=Encoder3_Data.PWM_Return;
    Vm[3]=Encoder4_Data.PWM_Return;

5. Conclusions
Based on the image collected by the OPENMV machine vision sensor and the LAB threshold of the target ball and the threshold information of the field color block collected by the OPENMV IDE, after multiple scanning and capture debugging, the target ball can be more accurately judged and captured, and the PID of the steering gear The adjustment test enables the grasping part of the machine to accurately transfer the grasped target ball to the throwing position and throw it accurately. However, considering the recognition sensitivity of the OPENMV machine vision sensor, the position error of the mecanum wheel movement and the influence of the field light on the judgment of the color threshold, there is a certain deviation in the throwing result of the intelligent throwing robot. In the actual use process, comprehensive debugging should be carried out in combination with the application site, equipment parameters and equipment utilization rate, so that the intelligent throwing robot based on machine vision meets the actual work requirements and has certain stability, accuracy and flexibility.

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