An Arduino-Based Robot for Teaching Drawing and Painting

Liu Jingyao, Yang Bin, Chen Tao, Zhu Ce, Liang Yongchao

Abstract

This paper presents a novel drawing robot system centered around an Arduino platform, which employs clips to attach two motors to a whiteboard. Ropes are wound around the motors and connected to a pen holder, with the other ends wound on spool reels, driven by stepper motors to control the drawing by either letting out or retracting the lines. The system incorporates a camera linked to a Raspberry Pi and Arduino, which, after recognizing images, replicates the corresponding patterns on the whiteboard. Our device facilitates a more naturalistic human-computer interaction for educational purposes, enabling the drawing robot to guide children in creating artwork on the whiteboard and to assist art teachers in their instruction.

Keywords Image Recognition; Motor Control; Arduino; Robot Design

1. Introduction

Nowadays, with the popularization of the application of all kinds of advanced technology and equipment and the support of relevant national policies, life in poor remote areas is getting better and better, but under the premise of safeguarding material life, it seems that the aesthetic education of young people is neglected, and the problem of the lack of education teachers in poor areas, the uneven level of education, and the inequality of education regions is very serious. At present, society pays great attention to aesthetic education, and the state has vigorously carried out poverty alleviation work, requiring the increase of tilting and support for the construction of the rural teaching force, and continues to implement the rural teacher development collaboration and attack action. Intelligent painting teaching robot with Arduino as the core, combined with image recognition and other technologies to achieve a more natural and scientific human-computer interactive teaching mode, replacing the role of professional art teachers. Through sophisticated algorithms to improve the painting effect, and in the teaching process to introduce interesting short stories, children can feel the joy of art learning at the same time, so that children in remote areas to learn art basic education opportunities.

2. Overall design of the robot

The painting teaching robot is composed of an image processing part, a mechanical control part, and an image processing algorithm. Firstly, the three-channel color image collected by the camera is converted into a single-channel grayscale image, and the adaptive thresholding algorithm is used to convert the obtained grayscale image into a binary image, and then the skeleton information of the binary image is extracted using the image refinement method, and the control part is assumed by Arduino, which receives the pixel information of the picture and then analyzes it into the Dir and Step signals of the drive motors, which are controlled by the After receiving the picture pixel information, the Arduino analyzes it into the Dir and Step signals of the drive motors, which are controlled by the I/O port of ULN2003 to drive the left and right stepping motors to rotate, and through the forward and reverse rotating action of the two stepping motors to drive the pen holder, the robot carries out the autonomous drawing. The system schematic diagram is shown in Figure 1 and the flow chart is shown in Figure 2.

3. Robot hardware design

3.1 Pen holder control design

The painting teaching robot uses Arduino to control two stepper motors to drive ULN2003, and its mechanical structure is mainly composed of the brush support part and the suspension traction part. The support part of the paintbrush is equivalent to the robot's palm, which is used to fix its device. The model of the brush support structure is shown in Figure 3. The device is connected by a fixed support so that the paintbrush can be accurately kept in the middle position of the fixed support and the opening and closing angle can be changed with the change of position. The design of the fixed support of the brush can adjust the center of gravity of the brush, so that the brush is stable and the diameter of the brush is significantly smaller when painting, thus ensuring the balance of the suspended traction part and avoiding shaking.

The brush control part consists of a stepper motor, servo, and brush support part. Compared with traditional drawing robots, this design innovates the flexibility and practicability of the robot based on accomplishing two-dimensional drawing operations in the vertical plane. Existing drawing robots have a fixed drawing pivot point and a limited working area, which affects their application range. The biggest advantage of this design is that the mechanical part of the robot can be disassembled and assembled, and the traction motor is very flexible and can be mounted in any drawing area so that the robot's attraction range is not limited and the size of the drawing area is no longer a limiting factor affecting the development of drawing robots.

3.2 Motor control part design

The core controller of this design is Arduino, the crystal oscillator is selected to be 16MHz.ULN2003 is also a 7-way inverter circuit, i.e. when the input is high, the ULN2003 output is low; when the input is low, ULN2003 output is high.

The power supply part uses a 5V power supply, DC5V directly for the stepper motor power supply, in addition to DC5V through the voltage regulator module output DC5V voltage for the Arduino power supply, positive and negative poles are connected to the VIN and GND pins of ArduinoMega2560. According to the design requirements and hardware configuration requirements, we use a 28BYJ-48 stepper motor, whose step angle is 5.625/64 degrees. If 1 revolution is required, then 360/5.625*64=4096 pulse signals are needed.

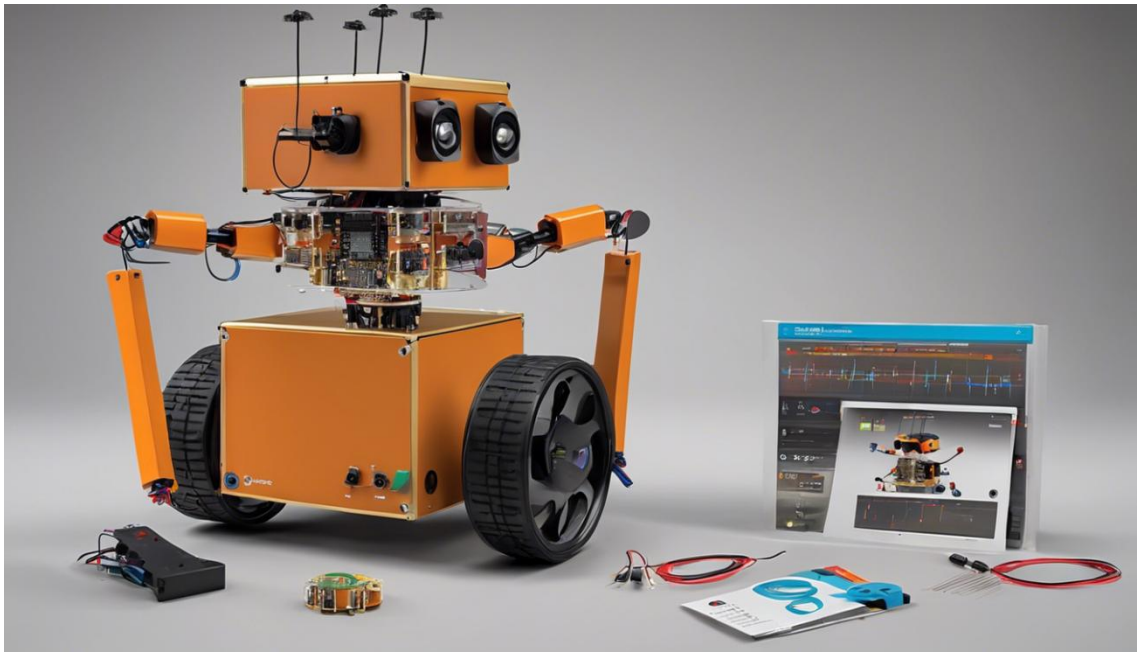
The stepping motor variable speed ratio of 64:1, the diameter of the winding shaft is 35mm, the average moving speed of the drawing pen is 13.7mm/sec, and the general speed is 9~27mm/sec. (The pen holder distance from the motor varies in speed, and the speed of horizontal and vertical movement is also different.) Figure 4 Figure 5 shows the ULN2003 pin function description diagram and 28BYJ-48 stepper motor structure respectively; Figure 6 shows part of the schematic diagram of the drawing teaching robot.

3.3 Image Processing

Contour is one of the important features of an image, and the extraction of image contours is a key technology for achieving precise drawing. Due to the difference between the object and the background in some image features, we used OpenCV for image edge detection and to make the image separated, to get a better image effect as well as compatibility with OpenCV at the same time, so we used a Lexus body camera connected to a Raspberry Pi and an Arduino.

The whole image processing process is as follows, firstly the three-channel color image captured by the camera is converted into a single-channel grayscale image, using an adaptive thresholding algorithm, the obtained grayscale image is converted into a binary image, to get the single pixel wide image outline, we have used the image refinement method to extract the skeleton information of the binary image.

To make the drawn image in the center of the canvas, we position the limit and crop the image to keep only the valid image parts, finally, we image the obtained image with the reference coordinates to get the Gcode file, in the next step the Arduino will control the motor to draw the image according to the Gcode code. Figure 7 shows the image after camera recognition.



4. Robot Programming

4.1 Principle of calculation

The robot uses a relatively well-controlled stepper motor with a force that meets its needs. The general air conditioner's air guide is pulled by this kind of motor. Connecting the wire with the program can control it to turn, a line of code, turn a bit, cycle 2048 times, and turn a circle. If you use a 35mm spool, turn a step, you can pull a 0.027mm line.

As shown in Figure 8, the two stepper motors are at point AB, and the motors rotate the bobbin, retracting and releasing the two lines, and the pen will move along. Just let motor A pull the line and motor B release the line and the pen will move to the desired position.

To move from D to the position of D', you only need to calculate the difference between AD and AD', the difference between BD and BD', calculate the length of the unwinding and unwinding wires, and finally calculate whether the motors rotate positively or negatively, and the number of steps they rotate. As shown in Fig. 9.

4.2 Brush movement process

Two drawing wires are tied to the pen holder and the other end is wound on the bobbin, which is driven by the stepping motor to unwind or retract the wire. The exit position of the drawing line in the holder is point AB (shown in Figure 10) The distance from the bobbin to the holder does not need to be calculated. The distance between these two points is the X_SEPARATION parameter (in mm) in the program. The X_SEPARATION value needs to be modified after measuring the actual width. The center of this segment is the X-axis origin, in principle left negative LIMXMIN, right positive LIMXMAX.

The position where the pen holder stays at power-on is the Y-axis origin. The vertical distance from the pen holder to AB is LIMYMIN, the value needs to be measured in advance, and try to ensure that the pen tip is in this position every time you turn on the computer, the error will be too large to produce distortion, X-axis is the same. Down is LIMYMAX, as long as the bobbin and format are long enough, LIMYMAX can be unlimited large. In general, keep the pen in the center of the screen and set LIMYMIN and LIMYMAX as large as you want.

To be able to flexibly draw arbitrary shapes, fine control of the drawing robot's movement is required. So the geometry of the drawing robot needs to be modeled. We take the two suspension points and the distance from the suspension points to the pen holder as a reference, we can get his reference coordinate system on the canvas so that we can determine the relationship between the rotation angle of the motor and the motion parameters of the drawing robot. Its drawing force parameter analysis diagram is shown in Figure 11.

The image does not expand infinitely, theoretically, the image is only affected by the distance of the AB point, and the wider the image the larger. In practice, it is not so ideal. The closer the penstock is to the vertical distance from AB, the greater the tension of the motor is going to be, and finally close to infinity. The stepper motor can not reach. So the highest point of the image can not reach the position of LIMYMIN. Nor can it be too close to the sides, because the pull of the horizontal phase becomes too weak again. So the optimal plotting area is labeled in the figure below. Beyond the optimal area, there will be a certain amount of distortion, the more beyond the area of distortion is greater, as shown in Figure 12.

5. Final results, function realization

We finally realized the function of the drawing teaching robot, which is driven by Arduino as the core, with two motors clamped on the whiteboard with clips, and a rope wrapped around the motors, leading to two pulling wires tethered to a pen holder, and the other end is wrapped around a spool of wire, driven by stepping motors, to put or take away the wires, and to control the pen to draw. A camera is used to connect the Raspberry Pi and Arduino, the camera recognizes the image and thus draws the corresponding pattern in the best area on the whiteboard.

The robot is characterized by the fact that the electrical and mechanical parts can be detached without being affected by the size of the drawing area. The stepper motor is small, easy to wire, simple to program, highly compatible, conductive, widely used, and durable with a long life. Both sides of the wire winding frame can be pasted on any wall, or the upper corner of the drawing board, no need to climb ladders to climb high, and the camera can autonomously recognize the pattern and painting. We actively respond to the national policy, very good use of painting robots to teaching whiteboards, more intelligent and specialized to teach children to paint and create, and stimulate children's interest in painting.

6. Conclusion

With the development of science and technology and the art industry, human life is becoming more and more intelligent, and young people should develop in all aspects, and basic art education is especially important. The combination of painting teaching robots and art education, actively responding to the national policy - education strong country, vigorously develop the education level of young people, to achieve multi-faceted development, to achieve the fairness of art education, intelligence, effectively improve the shortage of resources for today's art teachers, for China's art education cause to dedicate their share of power in the process can also improve the children's interest in painting, in the process, the children can also improve the children's interest in painting. This process can also improve the children's interest in painting.

References

1. Rao Xuefeng, Chen Ke. Design and realization of rope-pulling painting robot. Journal of Guilin Institute of Aerospace Industry,2019.

2. The Implementation Strategy of Aesthetic Education in Rural Primary and Secondary Schools.

3. Research Report on China's Art Education Industry 2019.

4. Li Li. The road to the development of rural art education in China. Hebei Normal University,2012.

5. Chen Bin, Zhang Xingyuan. Drawing robot based on Arduino. Computer knowledge and technology,2016.

6. AvinashKumarSingh, NehaBaranwal. Development of a self relianthumanoid robot for sketch drawing.

7. KazumaSasaki, KuniakiNoda. Visual motor integration of robot's drawing behavior using recurrent neural network.

Author Biographies

Liu Jingyao, Yang Bin, Chen Tao, Zhu Ce, Liang Yongchao

Binhai College of Nankai University, Tianjin, Tianjin 300270, China

Jingyao Liu is an undergraduate student. Her research interests are in Internet of Things technology.

Bin Yang, a master's degree student, and assistant lab technician. His research interests are intelligent perception and human-computer interaction, artificial intelligence, cloud computing, Internet of Things, and automatic control.

Tao Chen, undergraduate student. His research interests include Internet of Things technology.

Zhu Ce, studying in an undergraduate program. His research interests include Internet of

Things (IoT) technology.

Liang Yongchao, studying in an undergraduate program. His research interests include Internet of Things (IoT) technology.