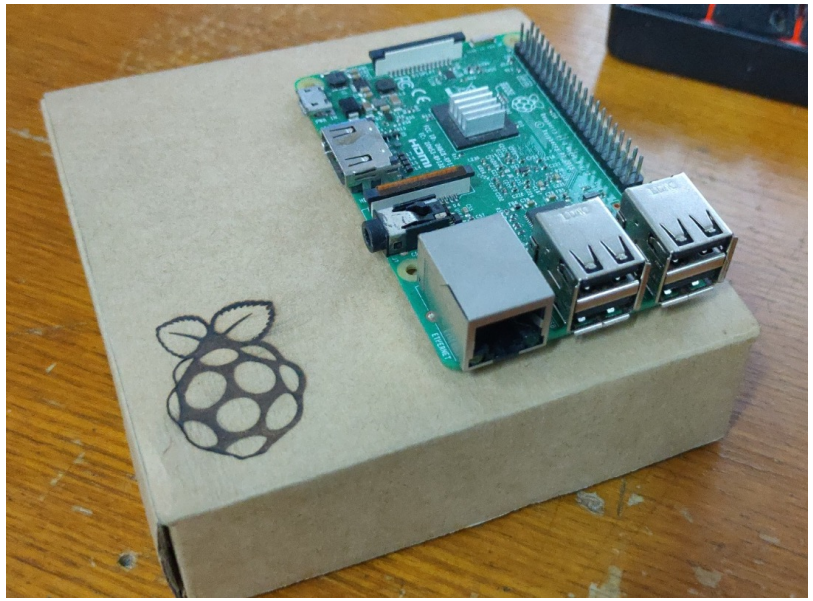
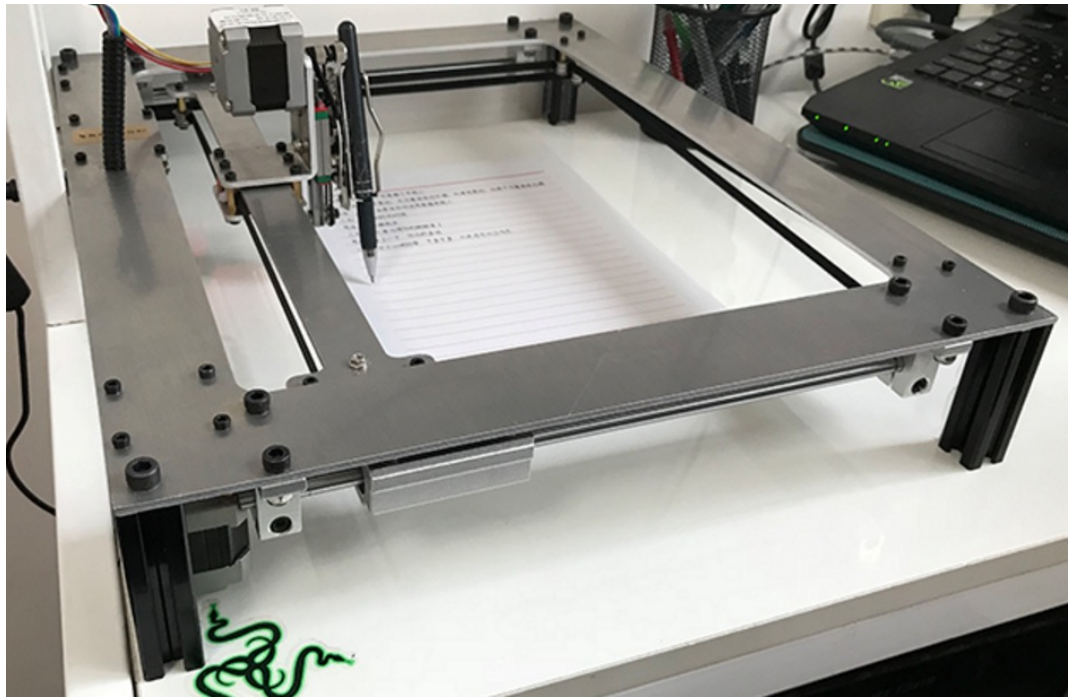
1 Introduction

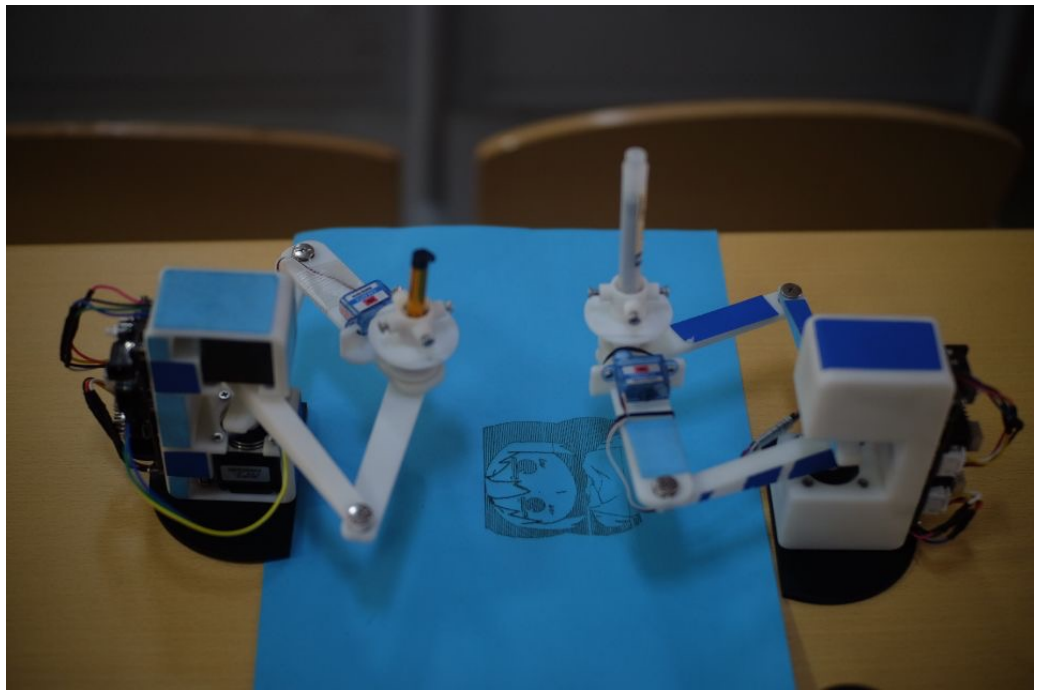


Draw patterns on different surfaces

In recent years, drawing robots have gradually entered people's field of vision. Unlike printers, drawing robots can draw on different surfaces, It can be made into many kinds of artwares.

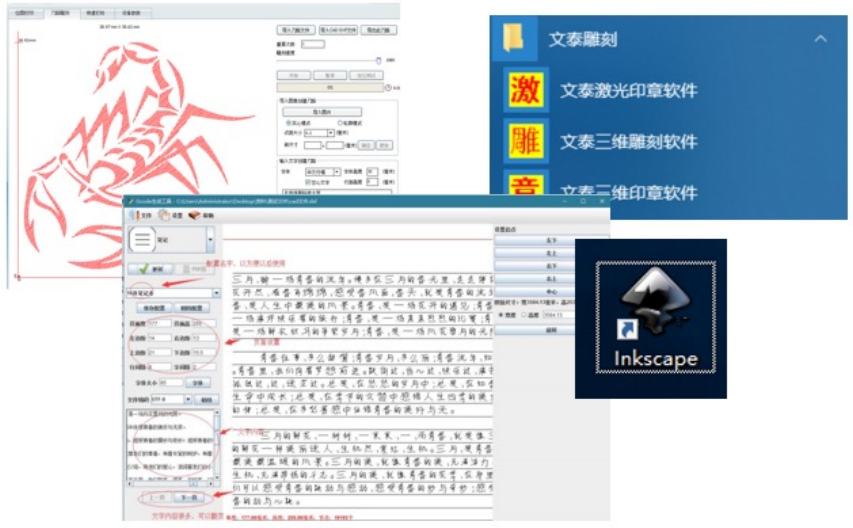
1 Introduction

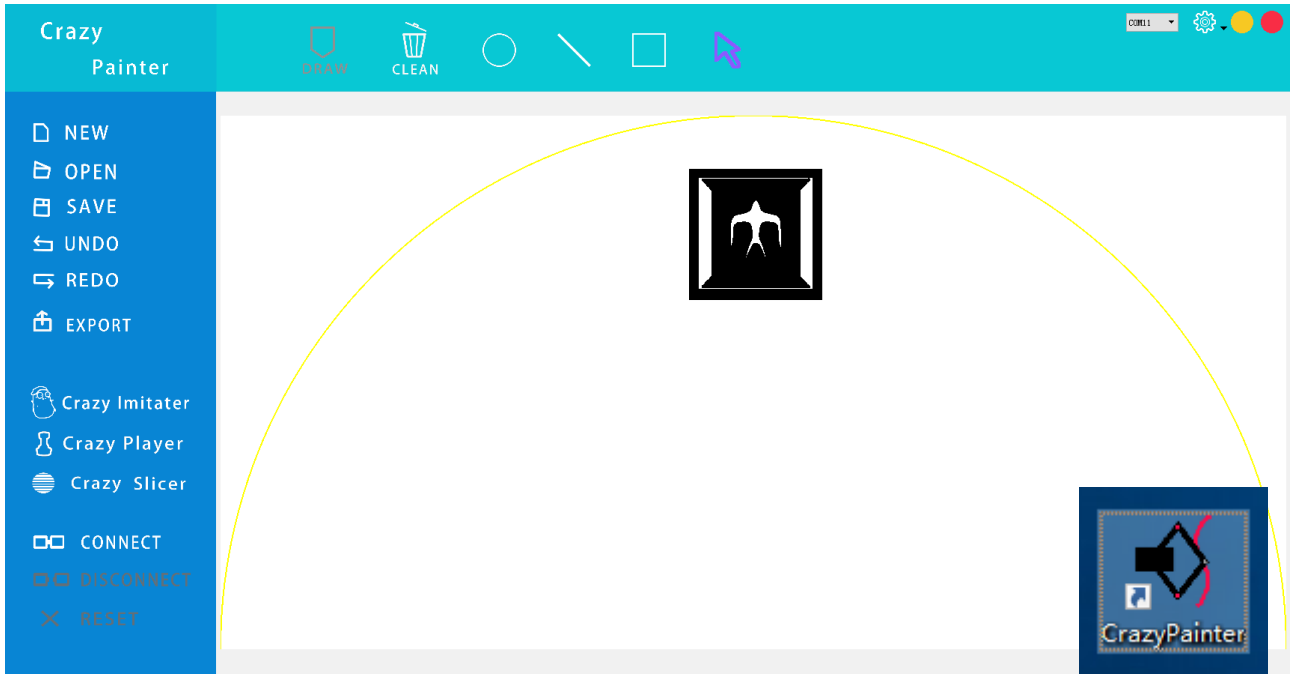




We designed a portable drawing robot that can write and laser engrave.
The mechanical structure is redesigned to solve the problems of large size and hard to use.

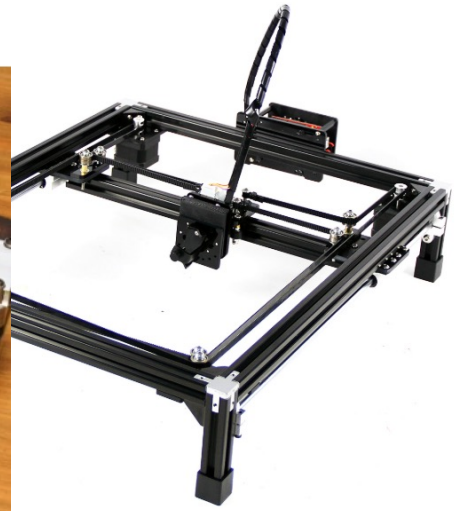
1 Introduction

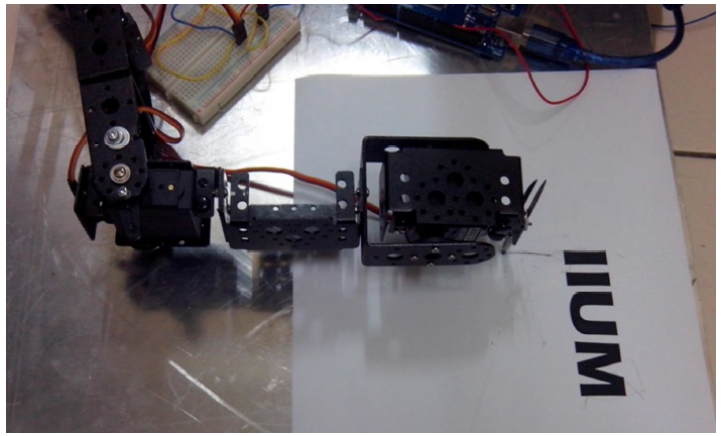


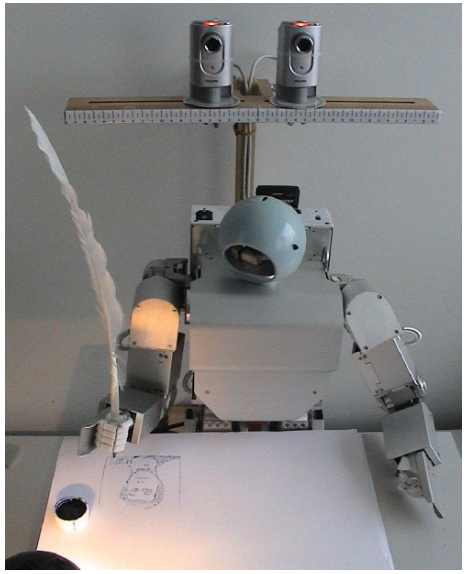


We redesigned the upper computer software, which is simple to use and has a relatively beautiful interface, which solves the difficulties of using traditional software.

2 Previous Works





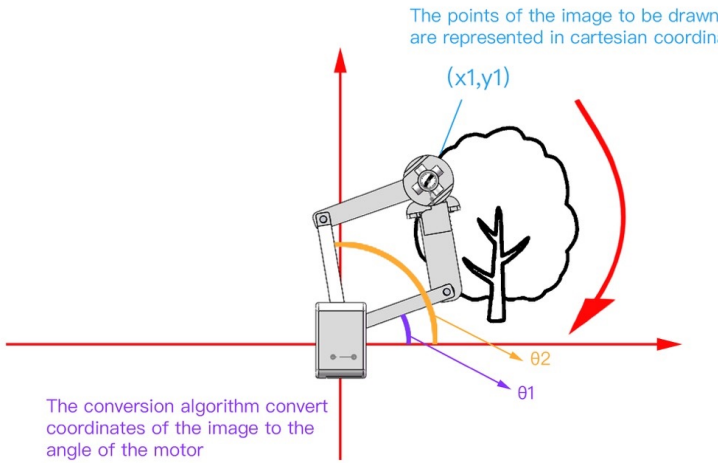


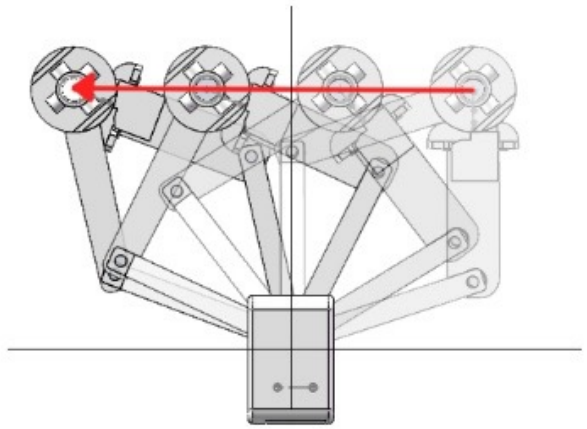
At present, domestic drawing robots are mainly divided into two types: 2-DOF on plane and Multi-DOF robot arms.
Their mechanical structure has been very perfect, the drawing effects are very good.

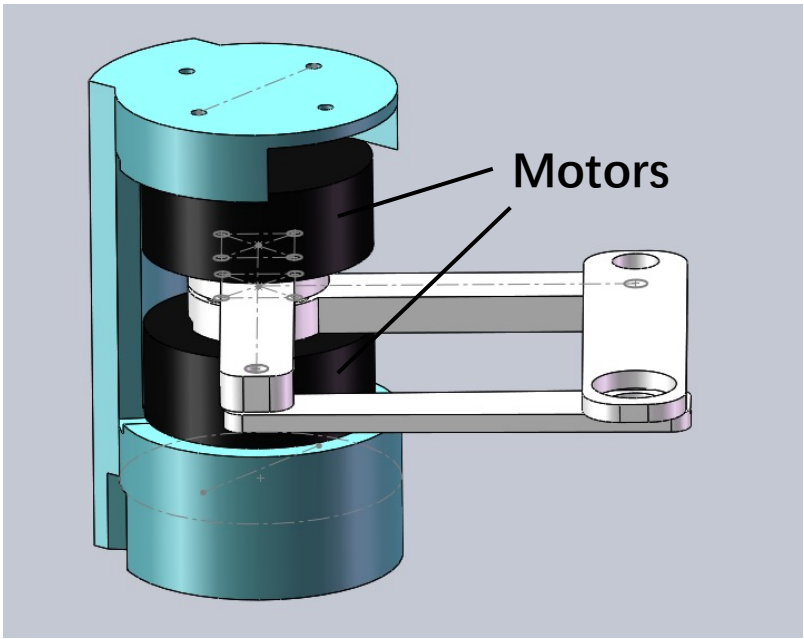
But their common problem is that they take up a lot of space and too heavy, so they are difficult to carry.
At the same time, the cost of the manipulator is very high, the multi-freedom of the manipulator is wasted, they are not fit for most of the users.

[1]AxiDraw https://www.evilmadscientist.com/category/emsl-projects/axidraw/
[2] Bhuiyan M, bin Hanafi M M. Two degree of freedom plotter using robotic arm[C]//Advanced Materials Research. Trans Tech Publications, 2015, 1115: 499-502.
[3] Calinon S, Epiney J, Billard A. A humanoid robot drawing human portraits[C]//5th IEEE-RAS International Conference on Humanoid Robots, 2005. IEEE, 2005: 161-166.
[4]DOBOT https://cn.dobot.cc/

3 Proposal of the idea



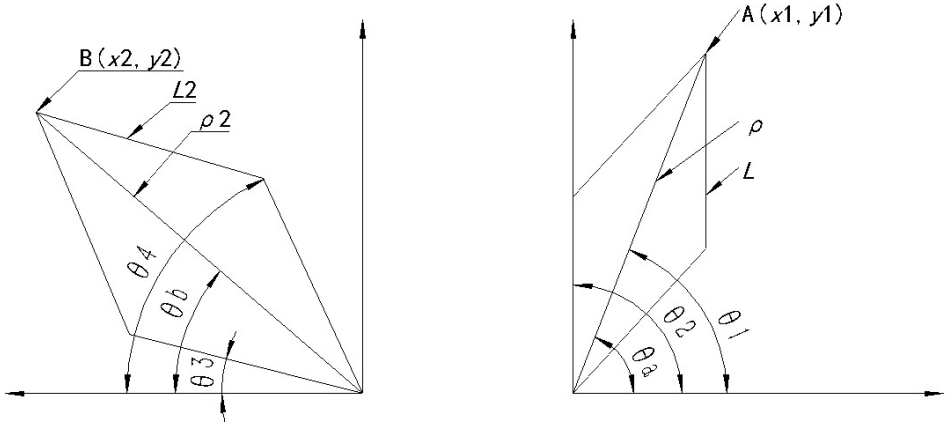




We founded that by controlling the rotation of two adjacent sides of the parallelogram, the position of the point on the opposite can be controlled. With this basic principle, the robot can draw a large range without taking up a lot of space.

We use two motors arranged vertically to control the two sides of the parallelogram, calculate the rotation angles of the two motors corresponding to the target point to be drawn, then we can realize the drawing function.

3 Proposal of the idea



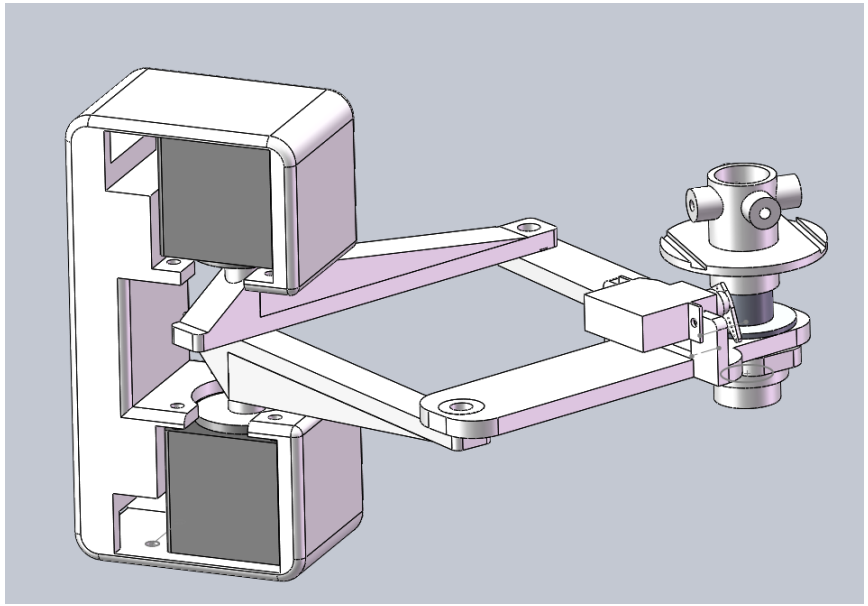
$$\begin{cases} \theta 1 = \cos^{-1}\frac{x}{\rho} - \cos^{-1}\frac{x}{2L} \\ \theta 2 = \cos^{-1}\frac{x}{\rho} + \cos^{-1}\frac{x}{2L} \end{cases} \quad (1)$$

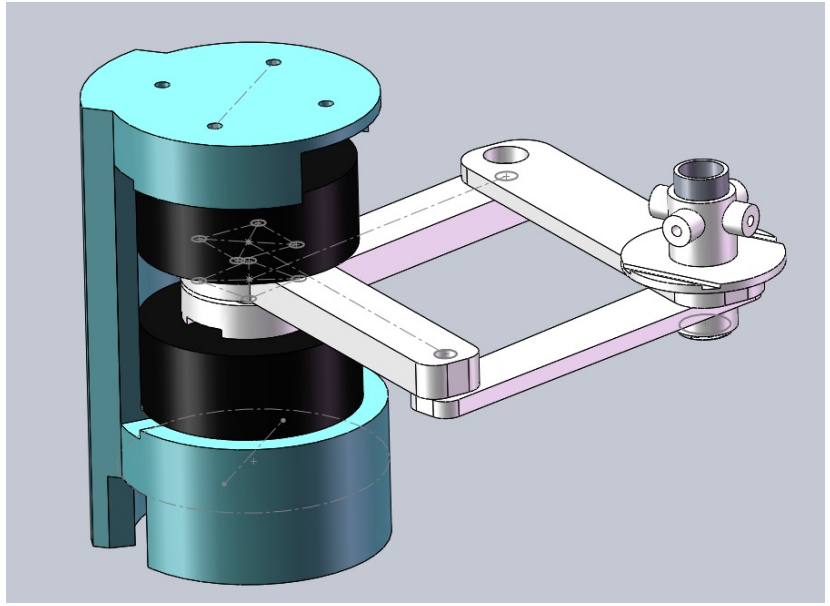
After calculation, the relationship between **the target point** coordinates in Cartesian coordinate system(x, y) and the **motors rotating angle** $\theta 1$,$\theta 2$ is shown in formula(1), Where L is the length of the robot arm.

We use stepper motors(in robot Version 1) and brushless DC motors(in robot Version2) to drive the robotic arm, combined with the basic PID control algorithm. Their control accuracy is high, which guarantees higher drawing accuracy.

4 Proposed Method

Mechanical Design





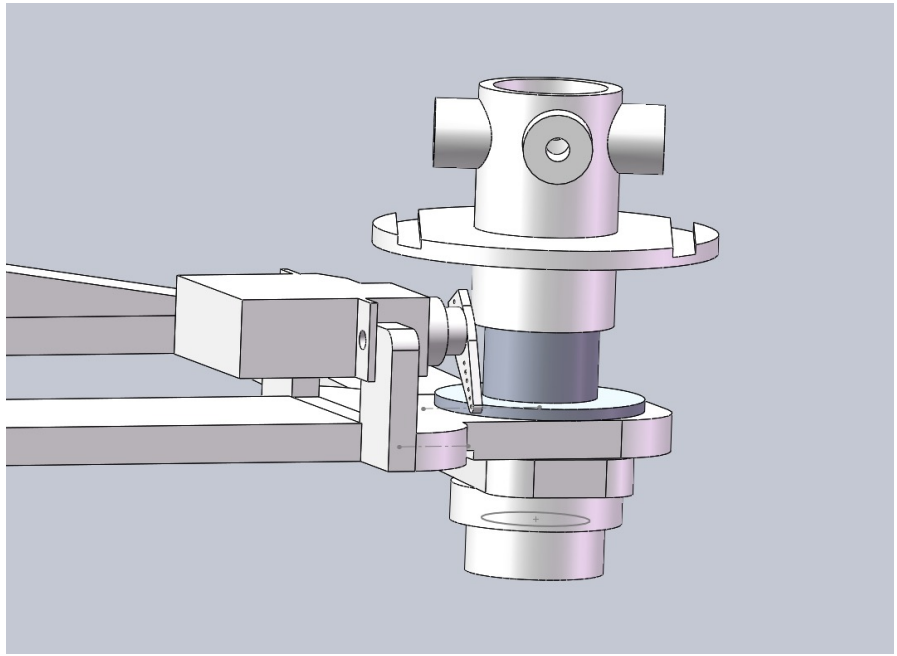
Version1

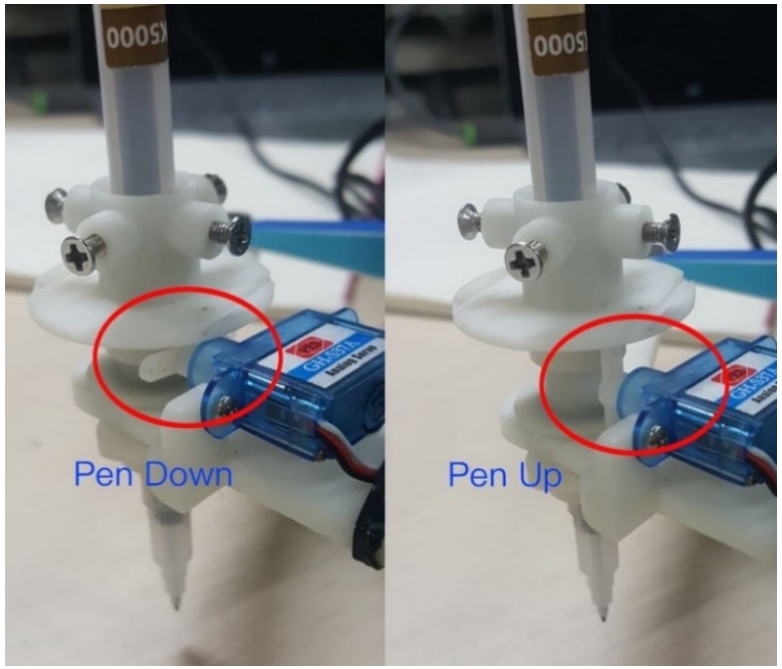
Version2

We use SOLIDWORKS for mechanical design and SLA 3D printing for molding.
We used ball bearings, butt screws, gaskets and many details in design to ensure the accuracy of the robot.

4 Proposed Method

Mechanical Design

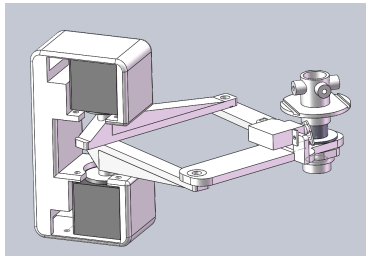


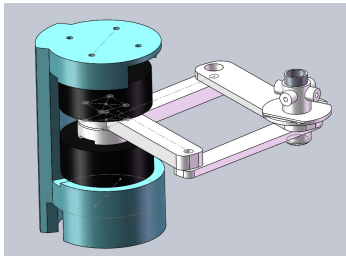


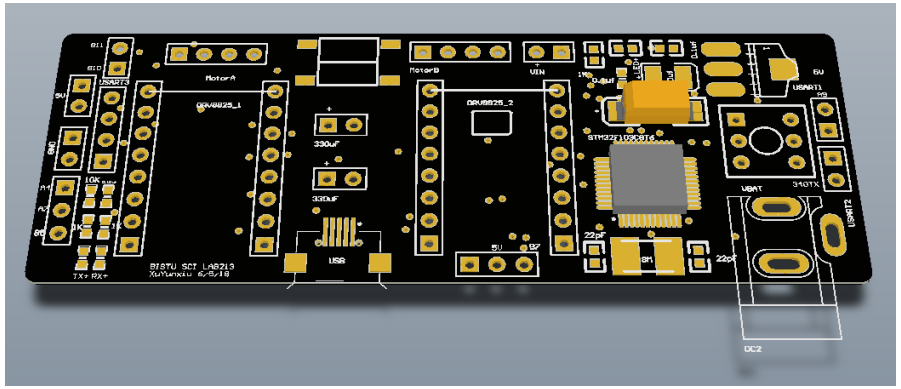
The robot can be mounted with a laser engraver or with a pen for drawing. Drawing with pen requires a flexible device for lifting and setting the pen, which is also a difficult point in design. We installed a small servo here to control its lifting and setting.

4 Proposed Method

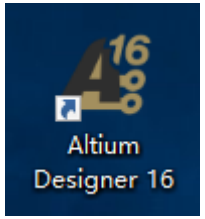
Circuit Design

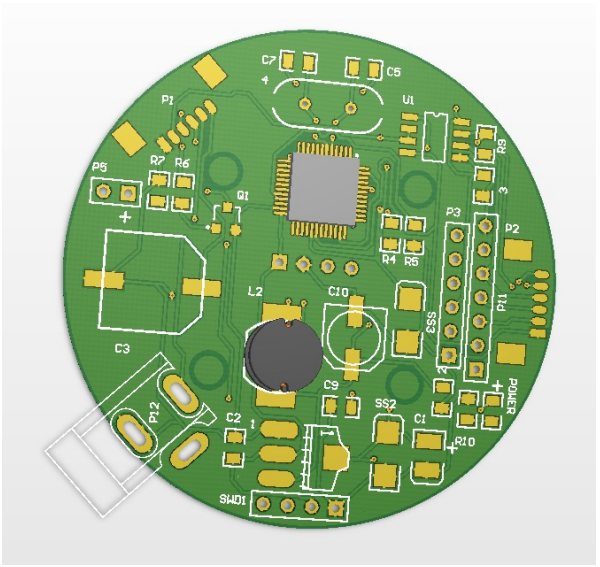






Version1



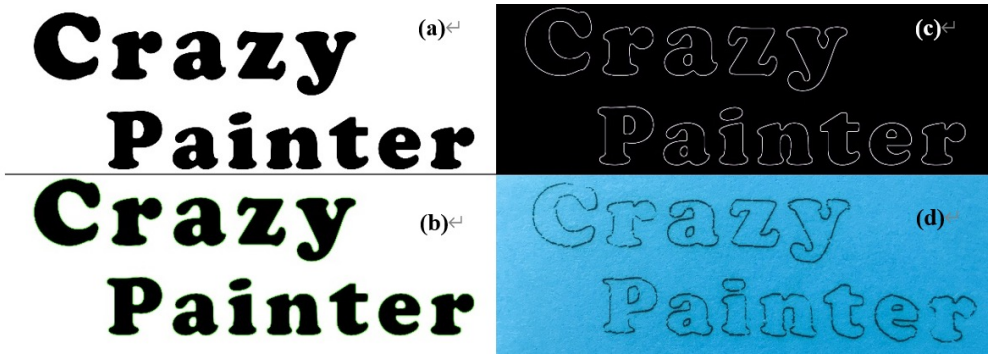


Version2

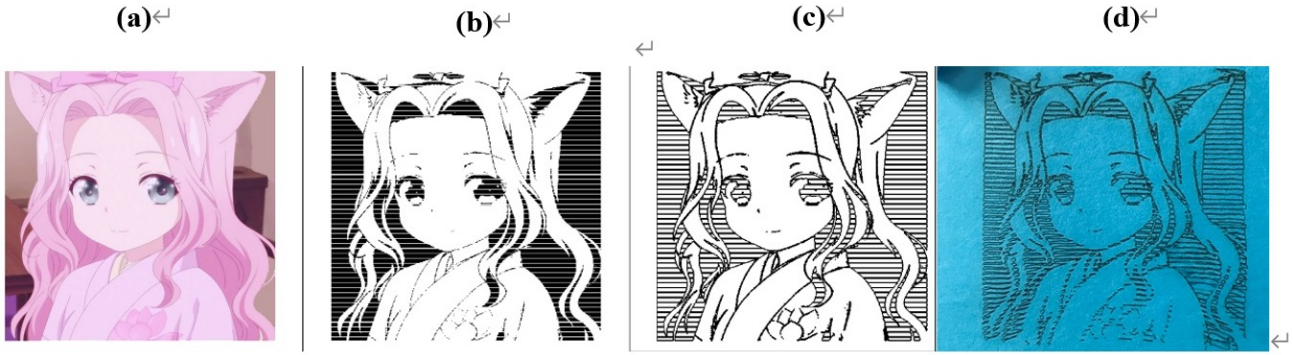
We used Altium Designer to design the PCB, installed STM32 as the main microcontroller, and also welded the power circuit, motor drive circuit, Bluetooth module and other necessary components.

4 Proposed Method

Software Design



(a) original image; (b) the original image and the extracted contour (c) Result of connecting the contour points with straight line; (d) The result of robot sketching.



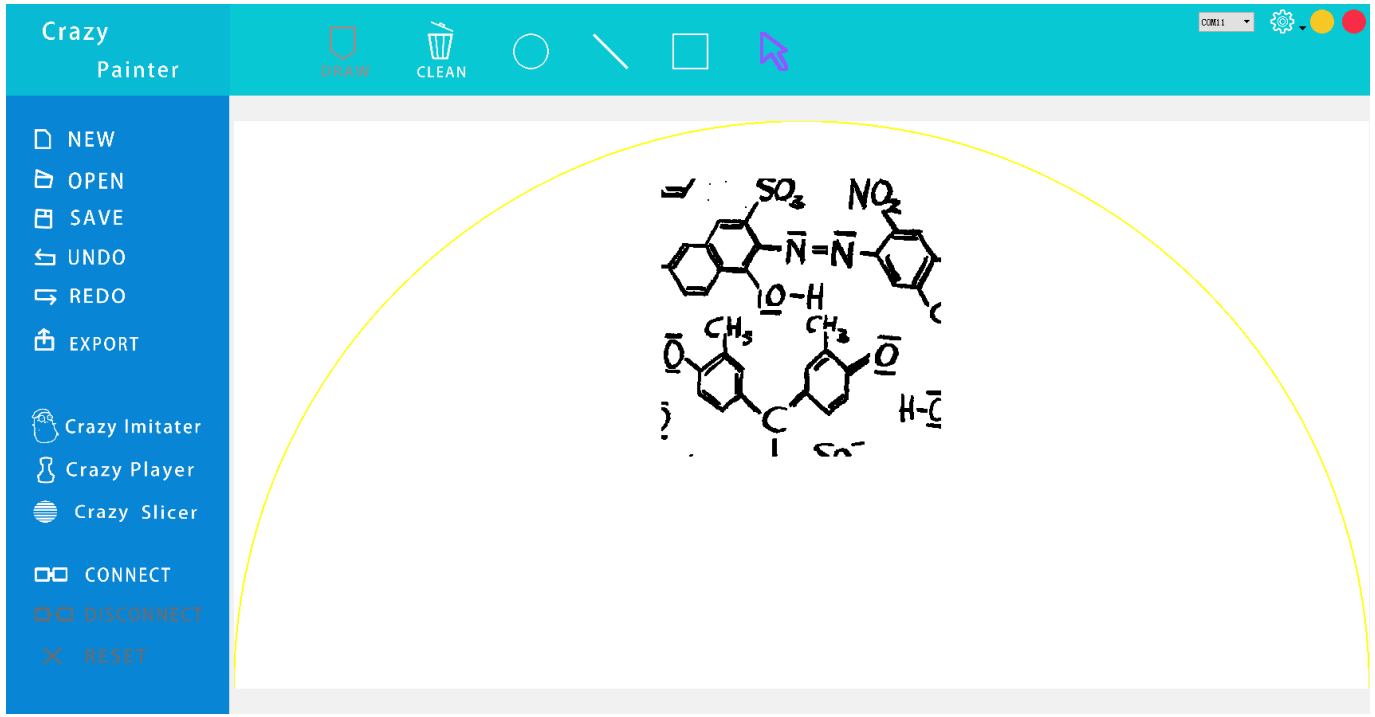
(a) original image;(b) Binary and add an auxiliary white line to the image;(c) Contour extraction of the image;(d) The results of robot sketching.

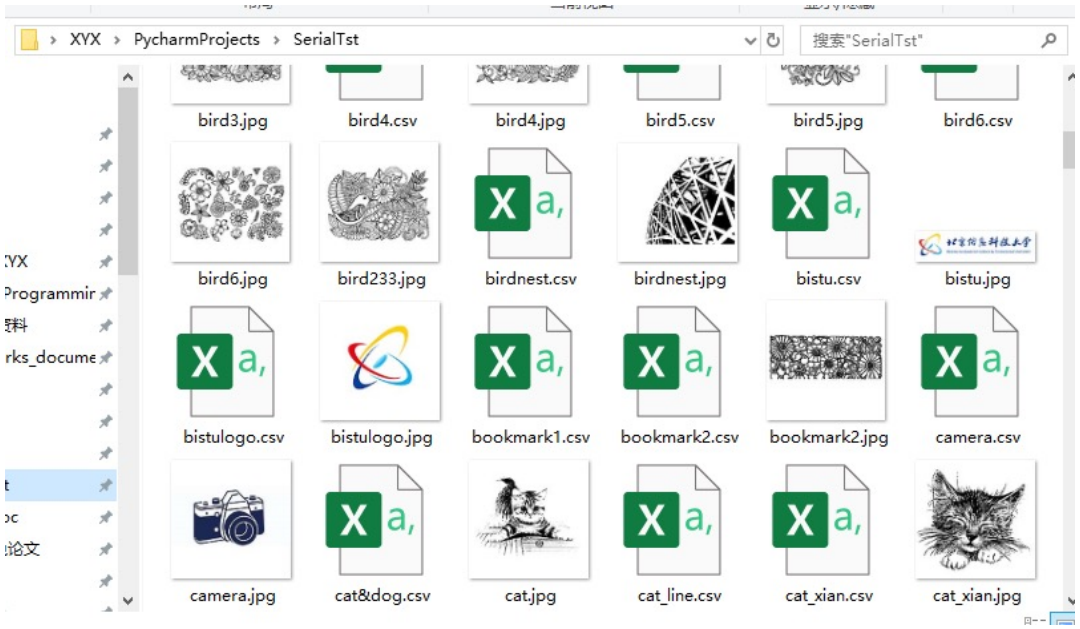
We need to convert the image to be drawn into the robot's executable coordinates. The drawn image is divided into solid and non-solid.

The left figure is the non-solid case. We use the contour detection algorithm to extract the contour points.
The right figure is the non-solid case. We transform the image into many horizontal lines. When the density of the lines is large enough, the solid image can be formed.

4 Proposed Method

Software Design

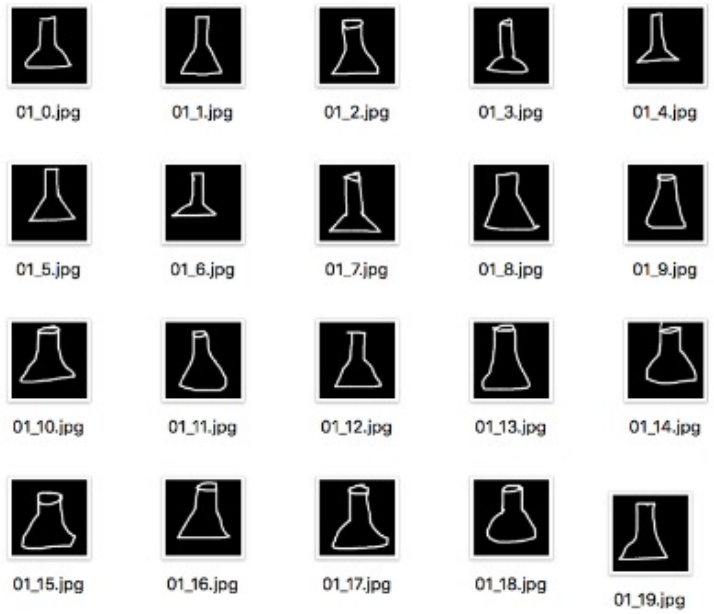




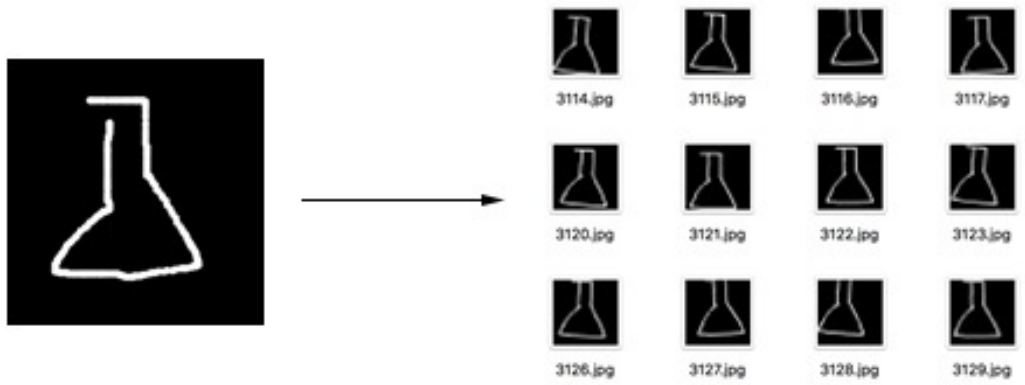
The converted image coordinate data is saved in CSV format. The upper computer software was developed by QT5, It can read the CSV files and assemble it into frames and send to the robot by Bluetooth. He also has the ability to display, modify and draw images.

4 Proposed Method

Software Design



A simple library that we drew ourselves



Randomly translated and rotate one image into multiple samples

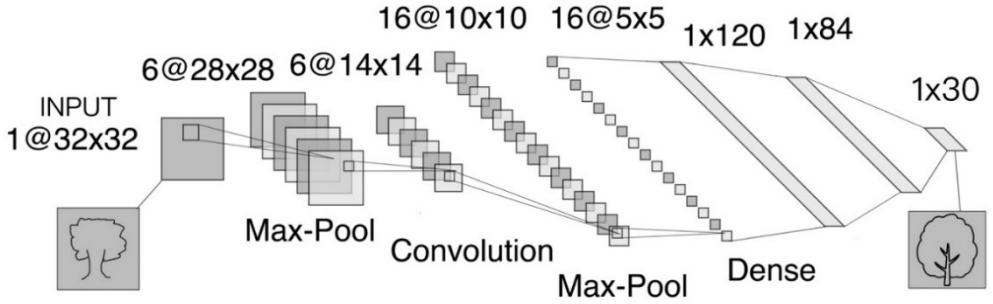


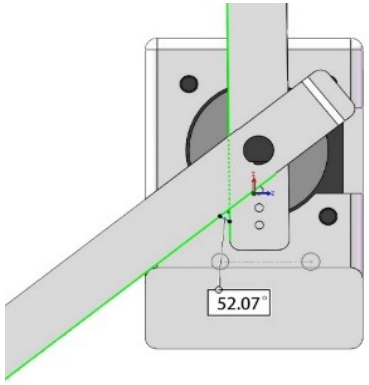
Diagram of our CNN

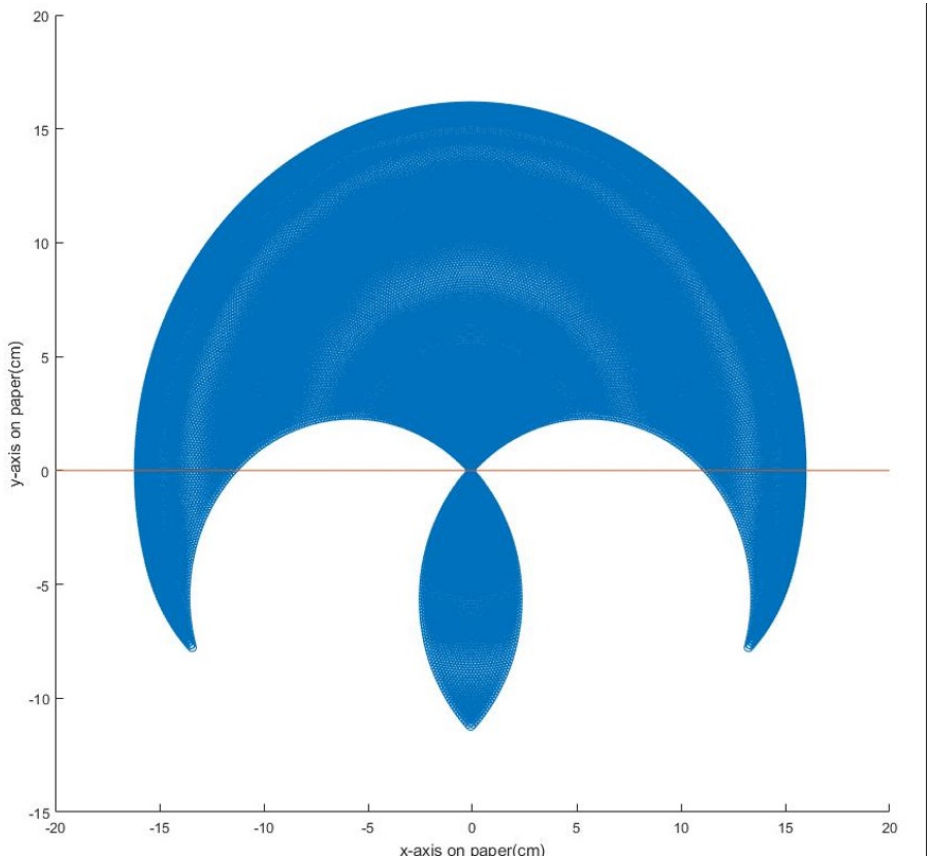
We have developed additional hand drawing correction software that allow us to convert rough hand drawn sketches into beautiful ones.

We used the basic LeNet-5 structure for development, and made an image library with 30 simple sketches for training.
We couldn't draw too many samples, so we drew a small number of samples and randomly translated and rotated them into more samples.

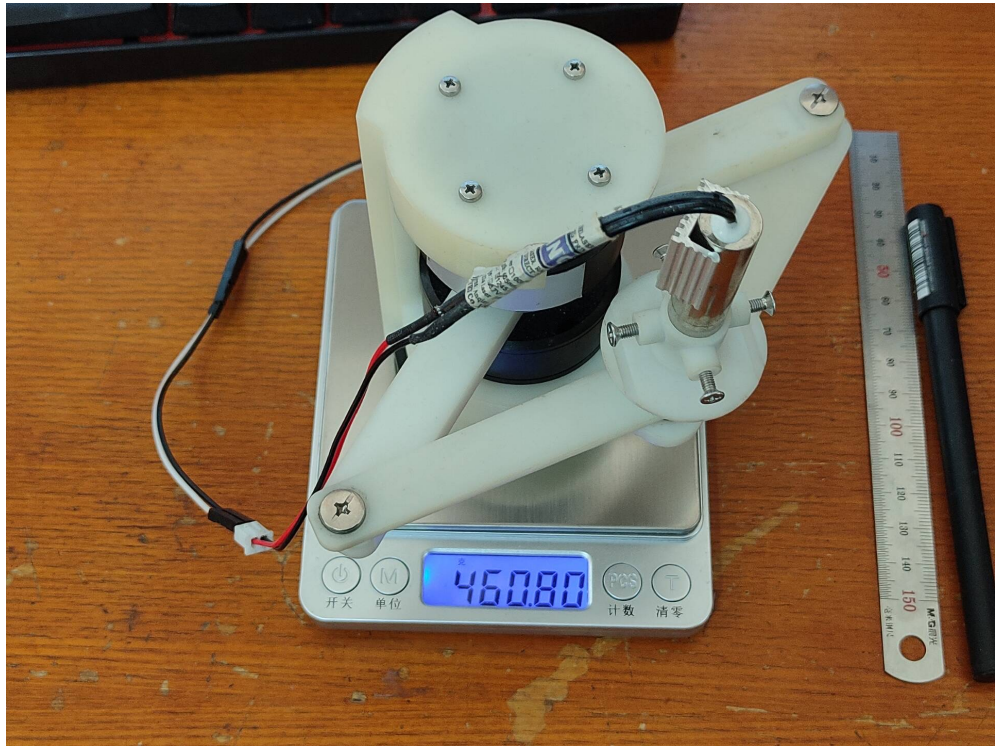
Example of hand drawing correction software

5 Results and conclusion





Region that can theoretically be drawn



The weight of the robot(gram)

Since the rotation range of the motor is limited, we set the rotation angle range of the motor as -45 ° ~ 225 °, and the center distance of the rotating shaft of the mechanical arm as 8cm:

The proportion that can be drawn is about 353cm^2 , accounting for 56.6% of a standard piece of A4 paper.
The proportion of the robot pedestal is 30.2cm^2, which is only 4.8% of the size of a standard A4 piece of paper.
The weight of the robot is only 460.8g, which is only 15.3 % of AxiDraw(3Kg).

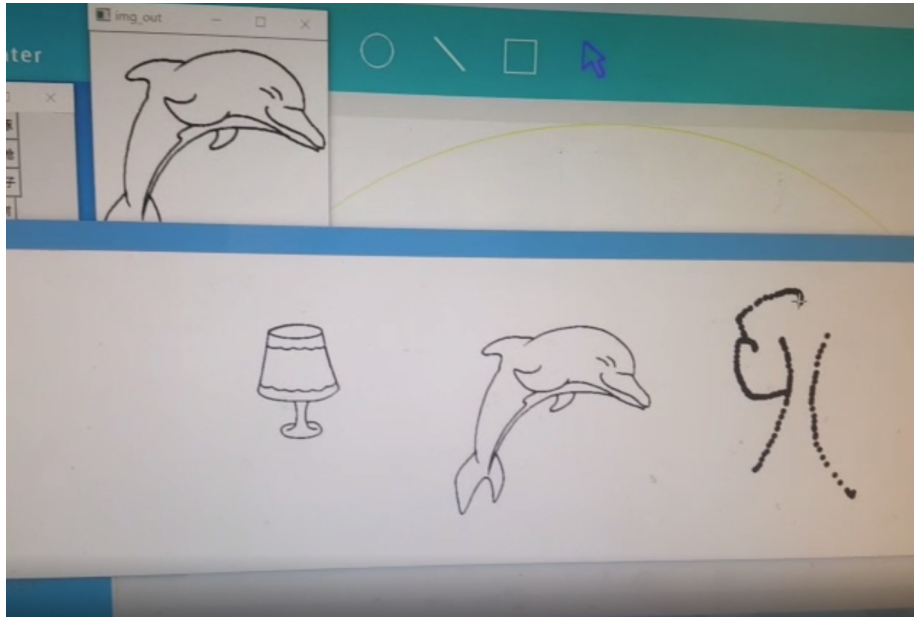
5 Results and conclusion

The accuracy of the hand drawing correction software

Person	Correct	Wrong	Total	Accuracy
Xu	23	7	30	76.6%
Li	17	13	30	56.7%
Luo	19	11	30	63.3%

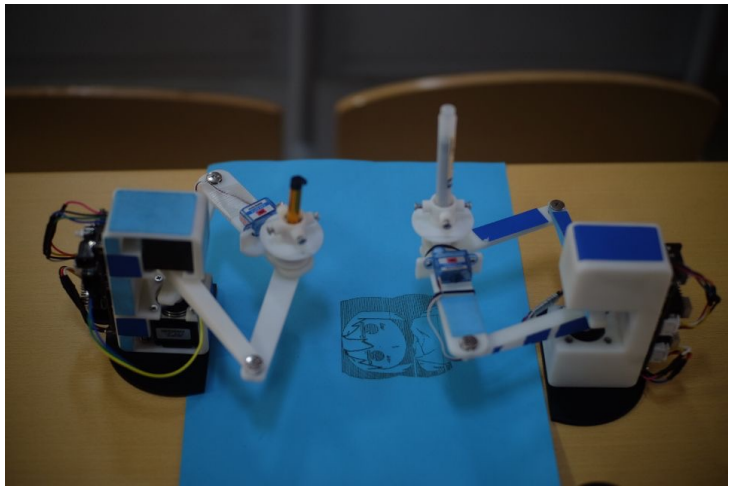
Since our sample library is not rich enough and different people have different understandings of drawing things, so we still choose our drawers (three people) of the library to redraw these 30 images to evaluate the results.

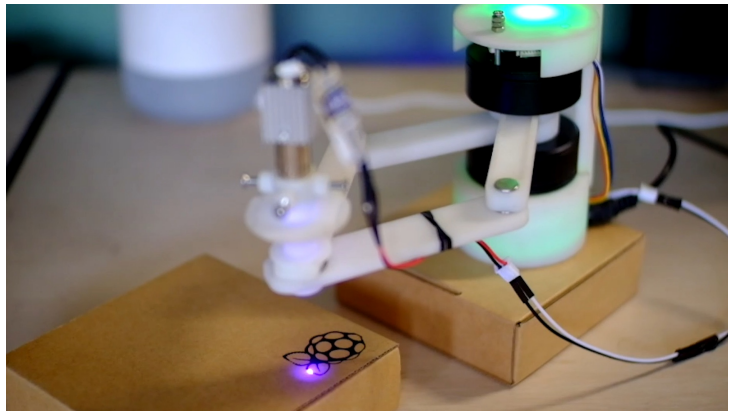
As the training sample is very small, we think the accuracy is acceptable.

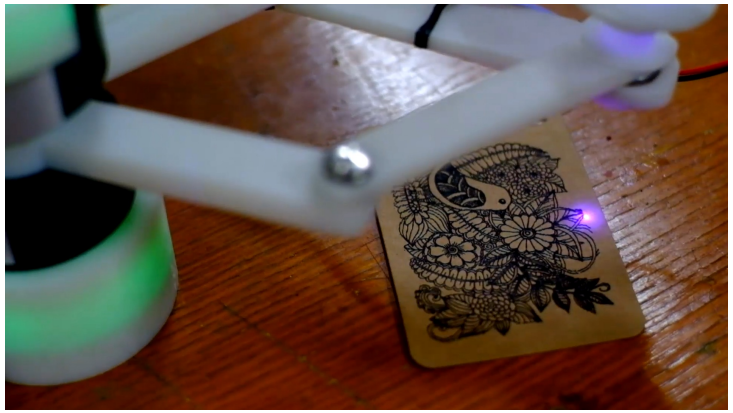


Hand drawing correction software

5 Results and conclusion







In **summary**, we have presented a **portable** drawing robot that can write and laser engrave. We redesigned the mechanical structure and greatly **reduced** the occupied **area** and **weight** without losing accuracy. We also made a upper computer software for assisting drawing to make the software **easier to use**.

However, there are some **limitations** in our system. **First**, its mechanical structure is relatively fragile, its mechanical components must be installed very well to maintain a higher accuracy. **Second**, the power of the laser cannot be so high that the laser engraving is slower because of the robot arm cannot carry much weight and higher power need more weight for heat dissipation. **Third**, the algorithm should be improved in the future to produce a satisfactory grayscale image.