

How to paint Einstein on the wall

This document is a popular science article, originally published by our store in Zhihu. The article introduces the principle of the wall painting machine, which can help the reader quickly understand the working principle of the wall painting machine. But it is not the instructions for use. For specific assembly and program debugging, please read " Wall Drawing Machine Installation and commissioning instructions "document.

Doubt, why paint Einstein? In fact, painting people, painting animals, painting mountains and rivers are all the same. I just found a celebrity who catches the eye. Do n't be more true, painting everyone is the same.

Speaking of wall paintings, did you think of these



If this is too earthy

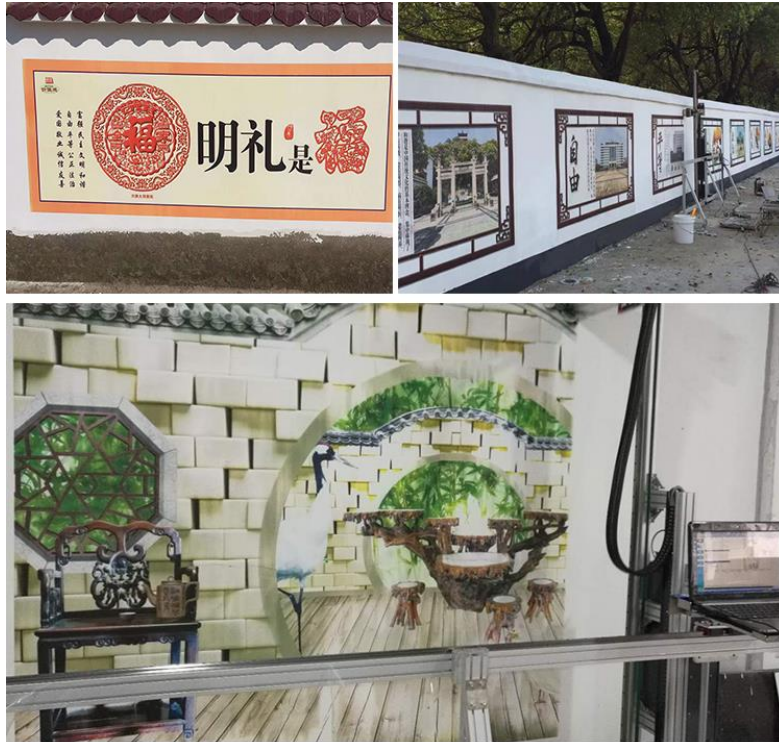


Then let's change something more elegant?



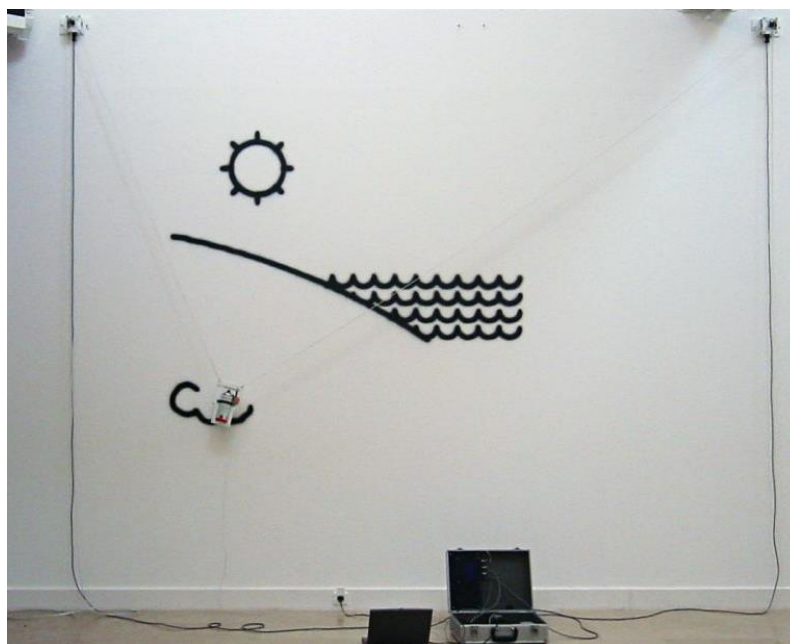
Or is it more detailed?

Regardless of his style of painting, these are not important, regardless of their style of painting, they are all practiced. Regarding the basics of painting, most of us are the same. Art classes are occupied by physics teachers. What can we say? It is not feasible to rely solely on manual work.



Since it can't be done by hand, then go to the machine! Wall printer to find out? Just 38888 ¥ The whole machine is delivered home, training in the morning, drawing in the afternoon, making money on the day 2 Monthly return, 1 Ben Ben Xiaokang. It seems that except for the expensive ones, there are no slots. How about we make a wall painting machine by ourselves?

The idea is this, find a favorite picture, and use a machine to paint it on the wall. Finished! Obviously, you can't be so sloppy. Since I don't want to build so many aluminum profiles, I need to put on a variety of stepping motors, drivers, inkjet heads, and ink. . . Let's make it simple. Get a pen and draw directly on the wall. As for how to control the pen. take 2 The rope is tied, is it OK to pull the rope?



already 2002 In two years, two talented designers came up with a Hektor device of.

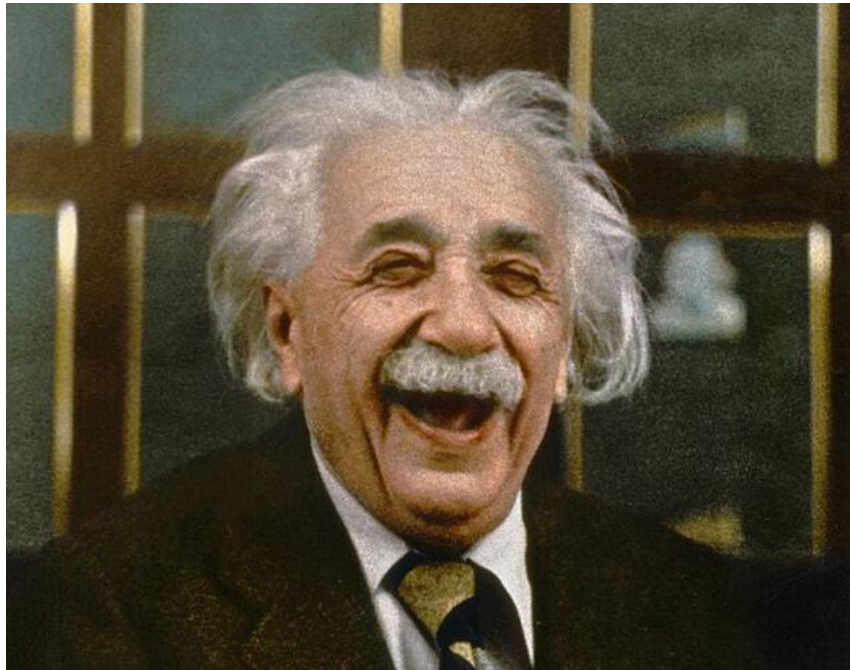
It consists of 2 Motor control 2 The rope pulls a self-spray paint and paints on the wall to paint. Later, the equipment of this structure was widely spread in the maker circle, with many names V Plotter Design , Polargraph , Wall Drawing Machine ,

Drawbot It does n't matter what it is called, 2 Motors 2 Rope (also 4 Motor, below 2 This structure can be laid flat on the ground), just pull a device that can draw lines and move it. The rope traction bracket moves on the wall and can be pulled to most areas of the wall (in fact, many positions cannot be reached, the best drawing area is a relatively small range.) There is another one that can control the pen to drop and lift the pen Institutions, even if you can't raise the pen and only finish one stroke, can you consider the mad cursive and calligraphy mode, haha. The above is the part of its hardware working principle.

We need one that can control the forward and reverse of the motor Arduino Or the Raspberry Pi, 51 , STM32 , PLC Whatever it is, something that can control the rotation of the motor will do. apart from Arduino I will not use the other few, so. In fact, their principles are similar, and there is not much difference in procedure.

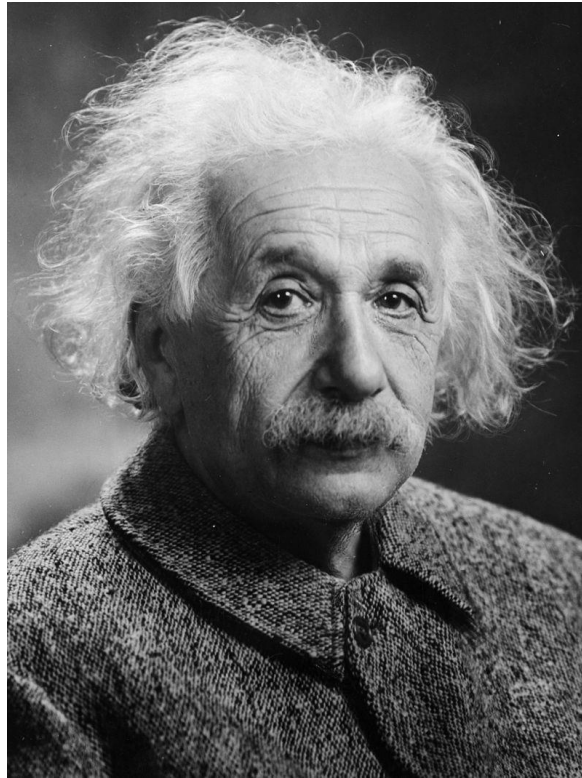
Now that the prototype is available, the working principle is also understood, think about the successful Zotye Auto. What are we waiting for? Practice it, Sao Nian, don't wait. Let's start painting Einstein.

first step: Google A picture of Einstein was downloaded.



It is really difficult to get started at the beginning when we encounter obstacles. We can only keep pens. Although they can be colored pens, we can only draw one color, so we need to find a monochrome photo. Actually we can develop one 12 Color pen stand, use different color pens for painting, even 256 Colored pen holder. . . Let's stop dreaming and start with monochrome. Multicolor is the fourth phase of the project (what are the second and third phase projects? Have n't thought about it yet)

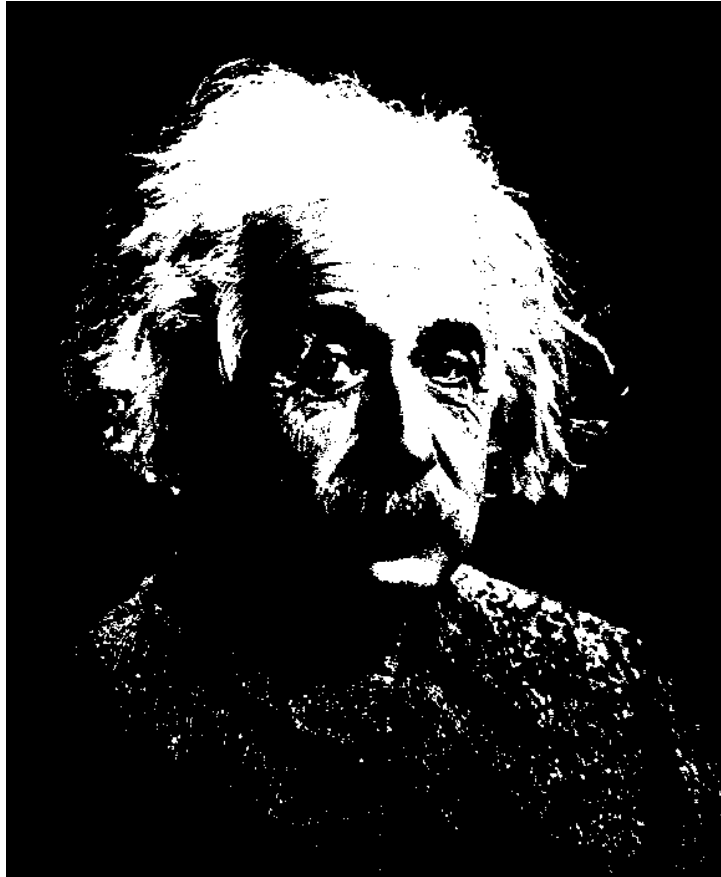
Step 2: Restart Goolge A monochrome Einstein



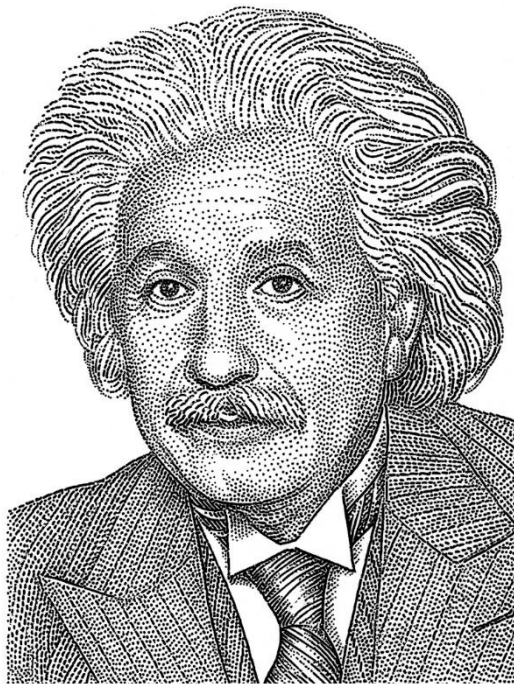
Wait, I encountered difficulties again. Although the photos are black and white, there are still many different grays, dark grays, light grays, deep dark grays, and light grays. . . . Obviously, our pen can't make strokes with different depths. (Actually, we can consider applying different pressure to the pen to make the painting feel like a stroke, and the pressure-sensitive screen can draw the shade according to the intensity. The second phase project is available) So we need a pure black and white photo without gray. Step 3: Continue Google A black and white piece of Einstein.



Well, I found the perfect black and white Einstein. Wait, what seems wrong? This person seems to be the godfather? continue searching.

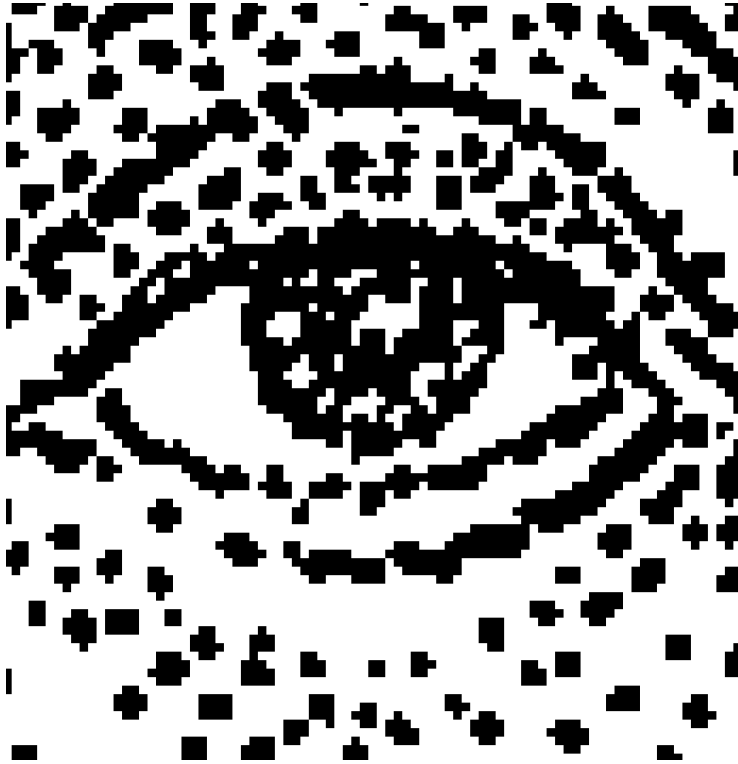


If i would PS You do n't have to be so troublesome, it should be like this, but unfortunately not P Keep looking.

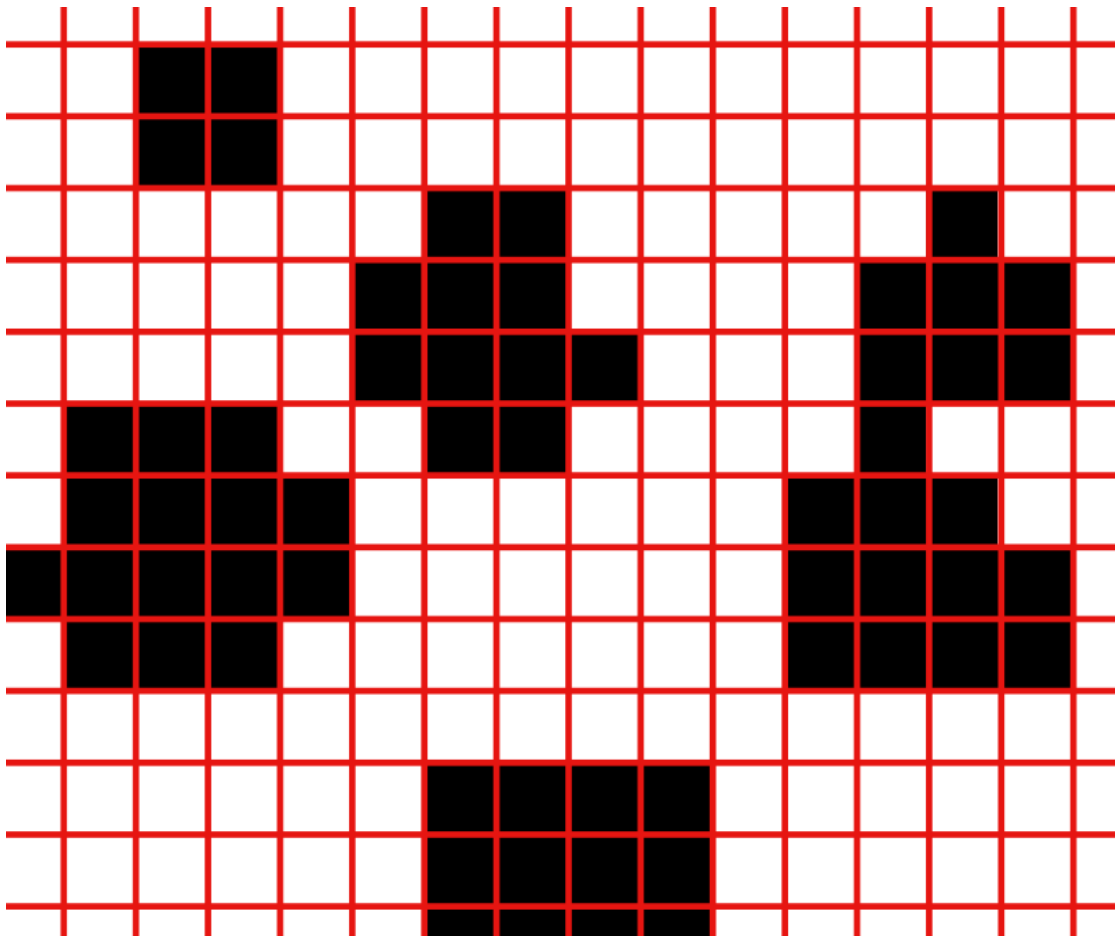


Found a black and white Einstein perfectly.

In the fourth step, the picture is a bitmap, which needs to be converted into a vector diagram to be drawn.



What is a bitmap, zoomed in is an image composed of dots.



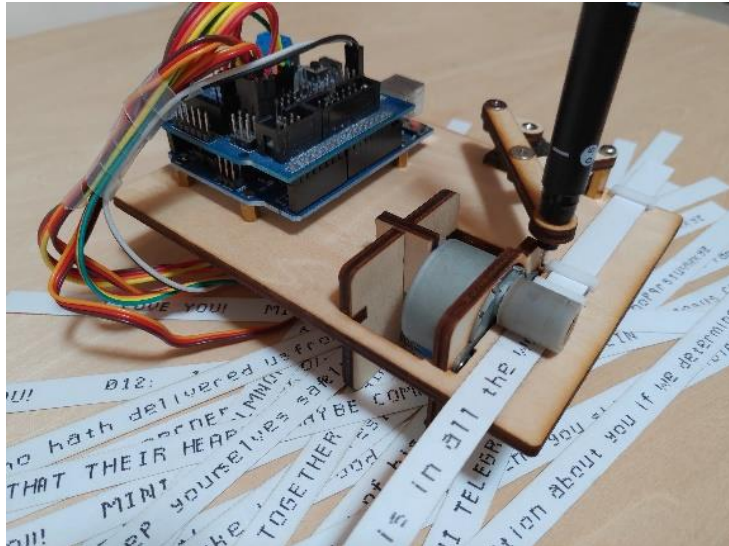
Zoom in again, each grid is a color, and many and many grids are combined to form a pattern. Jane above

Single Einstein was made by Heng 781 * vertical 1024 Altogether 799744 Composed of black and white grids. The black dot is about 23.1 Ten thousand.

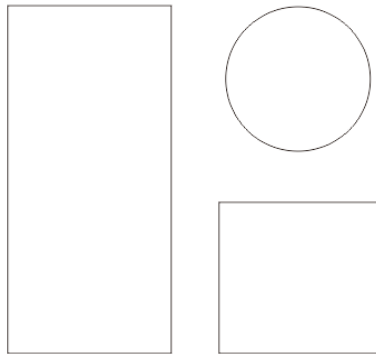
We can know the location of each black dot, and then use a pen to make dots on the paper. Every point 1 In seconds 63 Hours to complete, seems a bit slow.

Insert ads! When it comes to RBI, check out the telegraph machine in our shop

<https://item.taobao.com/item.htm?spm=a1z0d.6639537.1997196601.237.154c7484xanMS&id=576633734176> , This is the professional management machine.



Obviously, dot drawing is not suitable for our wall drawing machine, it is an artifact for drawing vector graphics. What is a vector?

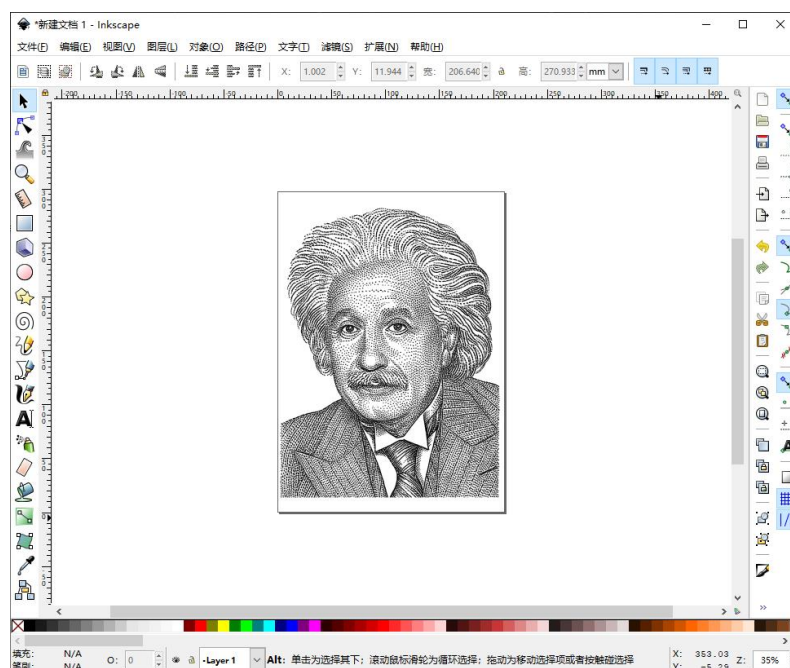


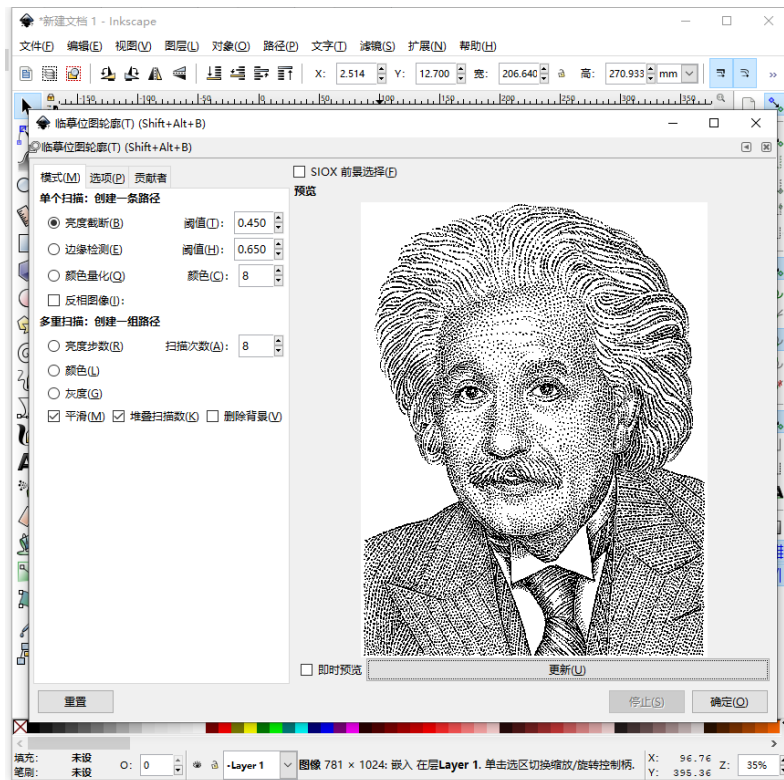
For some figures or lines, record the position, size, color, line thickness, and other information of the figure with numbers. Each time you see the figure, it is a figure that is calculated and then drawn (they are still in a dot matrix on the screen. The form is displayed). The advantage of this kind of graph is that it can be arbitrarily enlarged, no matter how big, it will not produce the kind of square dots in the bitmap. The disadvantage is that only relatively simple patterns can be represented.



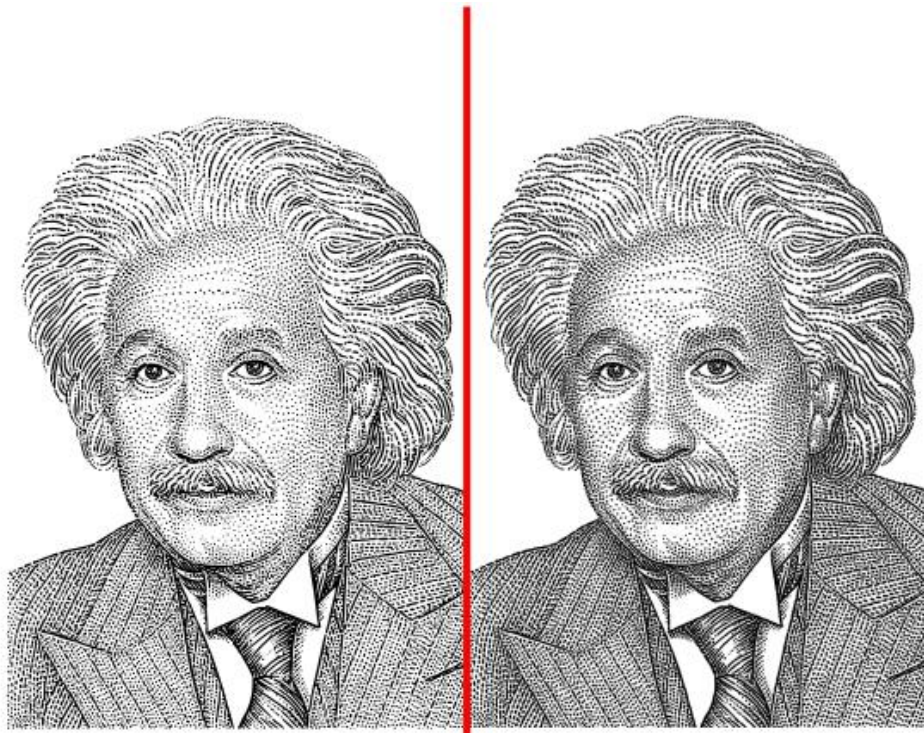
Slap, this is also a vector illustration, it is not simple at all. These are all drawn by the great god who has taken a serious art class (such as an art school with no art class, only art classes) (don't think about those who have not taken art classes). To add, vector graphics are best at curves, which can spike bitmaps. Each strand of hair in the picture above is a curve, plus different colors can show amazing details. Pull away.

Pull back to Einstein, how to turn a bitmap into a vector? A. Yes, but not all pictures are fine. There are many kinds of software can achieve this function. Let's talk about a free software Inkscape . (You can download it for free from its official website, of course, other paid software is also available)

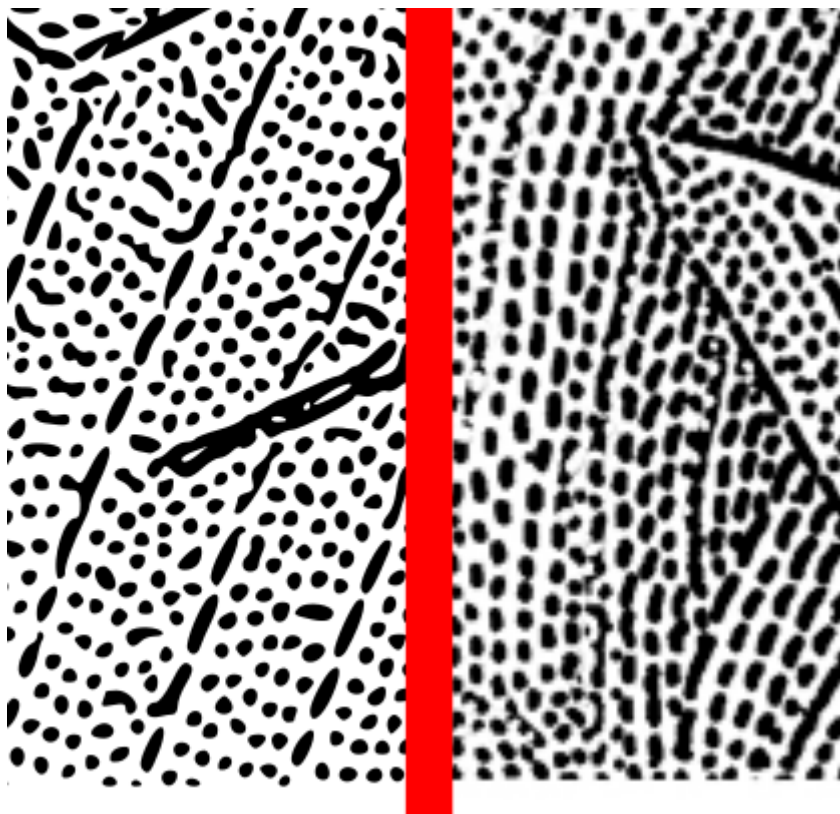




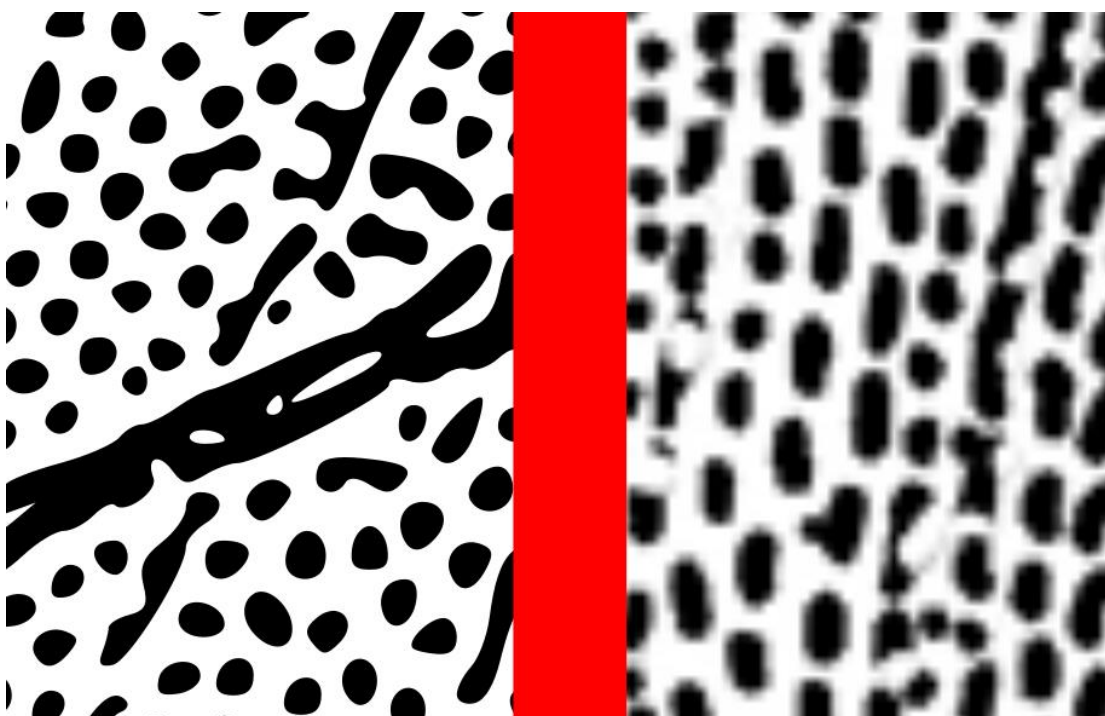
The operation is very simple, drag Einstein in, select Einstein, path-> copy bitmap outline, confirm.



At first glance, it is not possible to distinguish who is a bitmap and who is a vector.



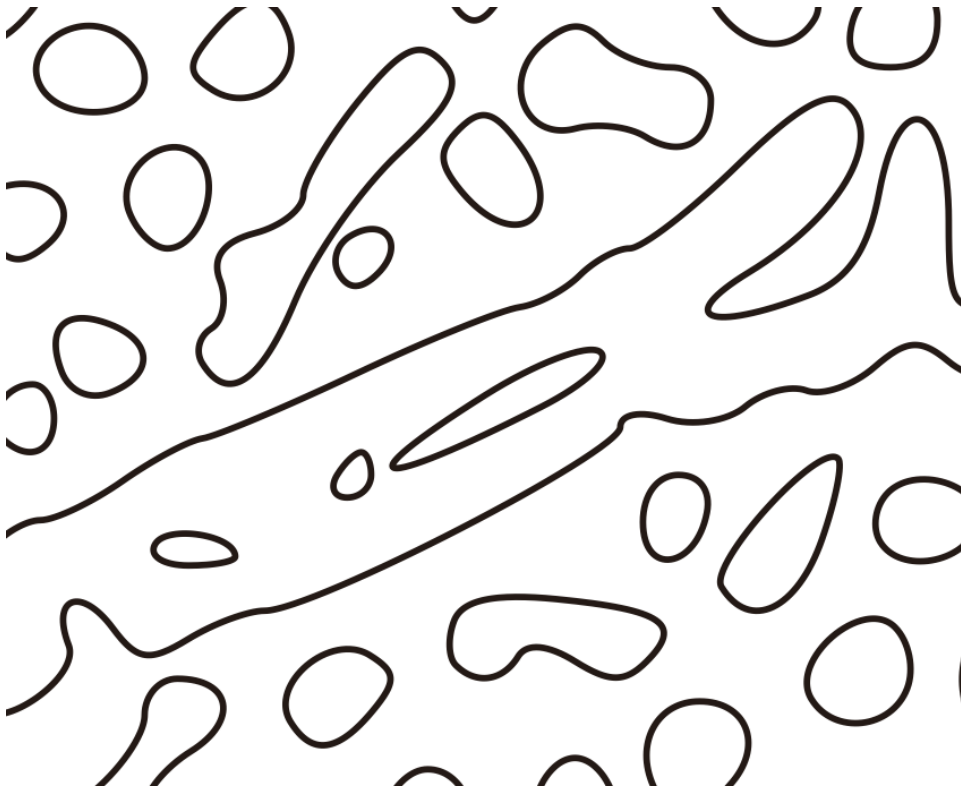
Zoom in to 200% You can see some clues.



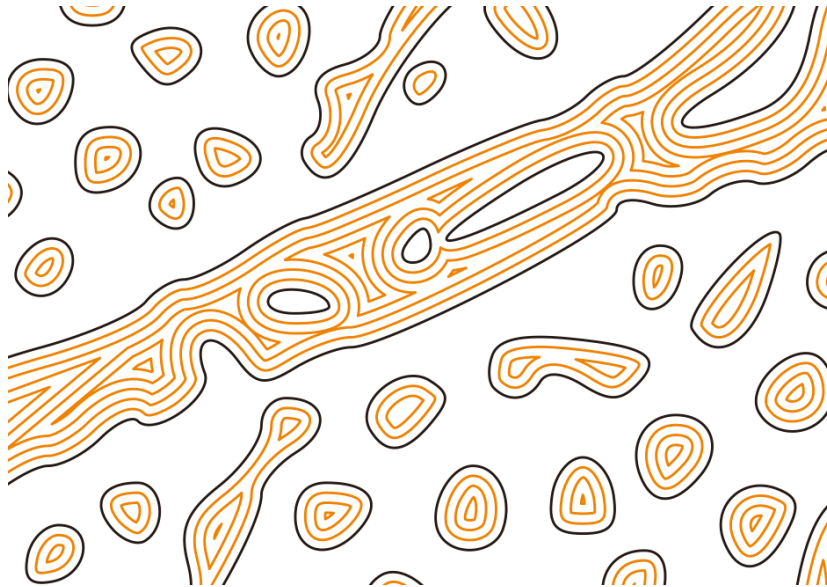
800% At that time, the bitmap was already terrible.



Vector graphics can continue to zoom in, zoom in, and zoom in again without pressure.



Let's ignore the problem of coloring first. Let the pen follow these paths to draw the outline. For the part that needs to be filled with color, take a few more trips back and forth like a child draws. Stroke first, then fill in the color, and you're done. But we have powerful equipment that can precisely control, draw multiple contours, and indent the width of one stroke each time to fill the color. As long as the pen moves along the path I planned, it can be drawn. These are not important, it is just a matter of time.

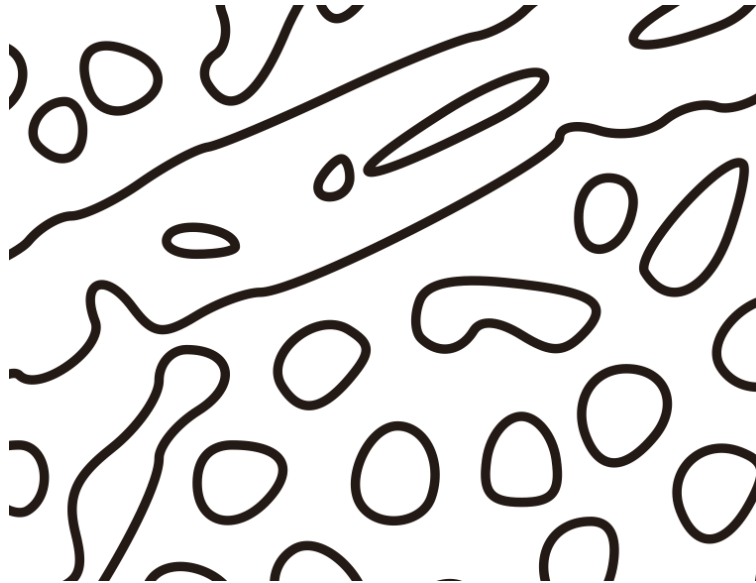


Black outline, yellow solid, as long as the pen width is calculated, it will become a solid color pattern.



Poor my intensive phobia! ! ! !

Actually this 2 There is no difference between these steps, all let the wall mural take a specific path. Therefore, merge similar items and ignore the second step to reduce the workload. Let's just make one outline first. Mainly for my intensive phobia or I can't continue.



Next, we need to create a program called G-code (G-code is the most widely used CNC programming language in the world), which is to convert the path in the pattern into a series of position coordinates, and then let the machine move along these coordinates little by little to process the pattern we need. In layman's terms, it is to tell the machine from coordinates xy move to $x_1, y_1, x_2, y_2 \dots x_n, y_n$. Do you think something is wrong? Horizontal and vertical straight lines can also be understood, how is the curve described? Does this seem to be a bitmap again? Yes, G-code is a bitmap. There is only a decimal point. In G-code there is almost no curve in it, and any curve is split into small straight segments (to avoid bar precision, some devices have a curve function, as long as the parameters of the curve are described, the machine can automatically follow the curve).



Even this German 5 Axis CNC machining center is also used G-code, Various small straight lines! Actually G-code The calculation is also a very complicated process. He needs to calculate the acceleration, deceleration, inertia of the various motors, the material of the workpiece to be processed, the size of the tool, the processing accuracy, the speed and so on. The precision machining center can achieve micron-level movement control, and what curve is needed for such high precision. . .

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5 G01 X0.948 Y-1.592 Z0
7 G01 X0.906 Y-1.219 Z0
3 G01 X0.886 Y-0.850 Z0
9 G01 X0.894 Y-0.669 Z0
0 G01 X0.918 Y-0.490 Z0
1 G01 X1.013 Y0.004 Z0
2 G01 X1.140 Y0.517 Z0
3 G01 X1.220 Y0.748 Z0
4 G01 X1.315 Y0.943 Z0
5 G01 X1.425 Y1.089 Z0
6 G01 X1.487 Y1.140 Z0
7 G01 X1.553 Y1.173 Z0
8 G01 X1.820 Y1.249 Z0
9 G01 X2.105 Y1.298 Z0
0 G01 X2.401 Y1.320 Z0
1 G01 X2.702 Y1.316 Z0
2 G01 X3.002 Y1.286 Z0
3 G01 X3.295 Y1.232 Z0
4 G01 X3.574 Y1.153 Z0
5 G01 X3.834 Y1.051 Z0
6 G01 X3.895 Y1.013 Z0
7 G01 X3.951 Y0.957 Z0
8 G01 X4.049 Y0.801 Z0
9 G01 X4.127 Y0.598 Z0
0 G01 X4.187 Y0.361 Z0
1 G01 X4.229 Y0.103 Z0
2 G01 X4.256 Y-0.160 Z0
3 G01 X4.264 Y-0.650 Z0
4 G01 X4.206 Y-1.713 Z0
5 G01 X4.121 Y-2.776 Z0
6 G01 X3.990 Y-3.830 Z0
7 G01 X3.902 Y-4.352 Z0
8 G01 X3.796 Y-4.869 Z0
9 G01 X3.710 Y-5.162 Z0
0 G01 X3.590 Y-5.448 Z0
1 G01 X3.443 Y-5.728 Z0
2 G01 X3.278 Y-6.004 Z0
3 G01 X2.921 Y-6.549 Z0
4 G01 X2.578 Y-7.097 Z0
5 G01 X2.219 Y-6.558 Z0
6 G01 X1.848 Y-6.021 Z0
7 G01 X1.674 Y-5.749 Z0
8 G01 X1.517 Y-5.472 Z0
9 G01 X1.383 Y-5.188 Z0
0 G01 X1.278 Y-4.895 Z0
1 G01 X1.192 Y-4.543 Z0
2 G01 X1.131 Y-4.185 Z0

```

Pull it back, we have to the millimeter precision ok of. (Actually our theoretical resolution can

achieve 0.027mm , Even if the actual accuracy error 1 Orders of magnitude 0.27mm The resolution is quite amazing) Draw a picture of Einstein, completely crushed.

Inkscape You can make a vector G-code Save, many ways please Google A lot of it, Baidu also made up. Here is omitted.

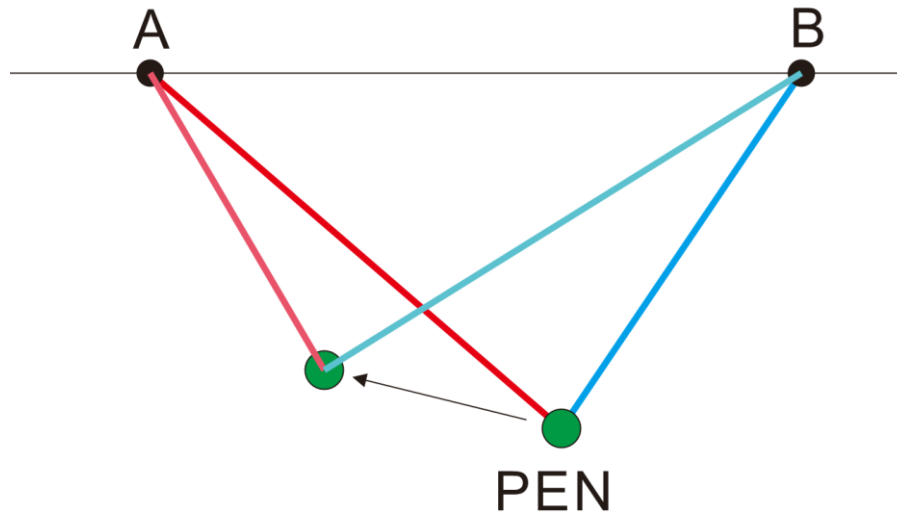
As above, we have turned a photo into a complete list of location coordinates. As long as we let the equipment go to the location we specified, and then to the next location, OK Too.

How to get to a predetermined location? We can study the subject.



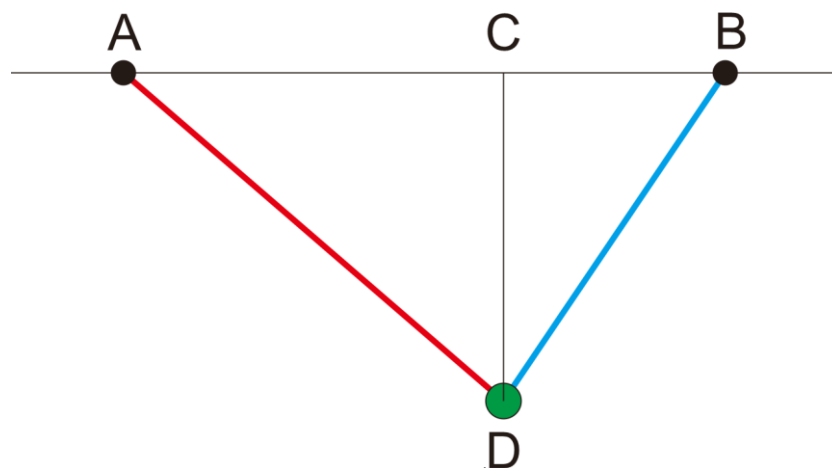
Stepper motor, please Google a bit. Simply put, it is a motor that can precisely control the rotation angle. Ordinary motors can be turned on when power is turned on, and how much it can be turned on can only be estimated, and cannot be accurately controlled. hold Live, there will be a large load will be pulled in the reverse direction. The stepper motor can not only accurately control the speed and angle (the minimum angle of industrial stepper motor can be achieved 0.9°, can achieve higher accuracy with a reduction gear), and can still be maintained with a certain force when it is at rest (cannot be external force

Turn). We used relatively well controlled 28BYJ Stepper motor, with its own reduction gear, strength can meet our needs. Generally, the air deflector of the air conditioner is pulled by this motor. After connecting the cable, we can use the program to control it, without the need for additional drivers, power supplies and other inexplicable equipment. You don't need to know the subdivision and pitch angle of the stepping motor. . . Such inexplicable properties. One line of code m1. Steps (1) , Turn around. cycle 2048 Once, turn around. If used 35mm The spool, in one step, can be pulled 0.027mm Line. It's that simple, even if the stepper motor is finished.

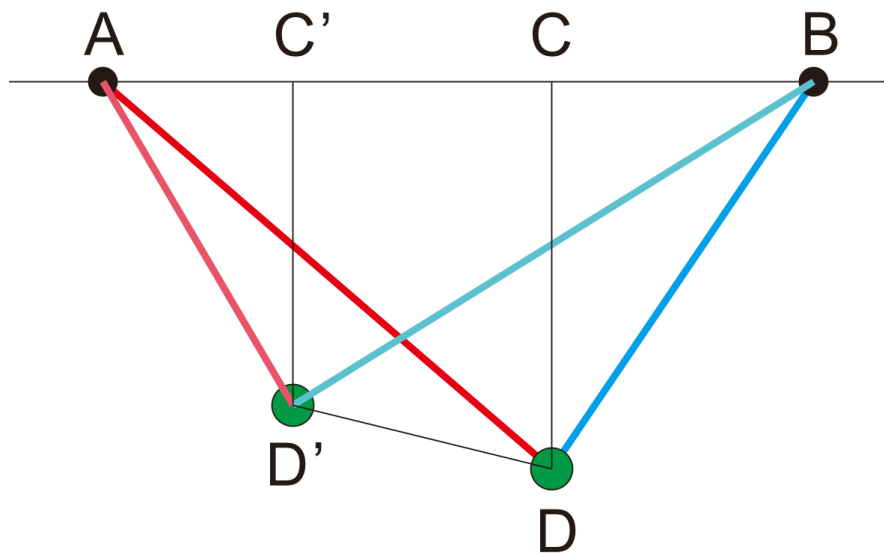


Next, see how the two lines pull the nib. Two stepper motors AB Point, the motor rotates the spool, retracts the two lines, and the pen moves accordingly.

Just let A Motor cable, B When the motor is put out, the pen can be moved to the desired position. How much distance does the line need to receive and how many lines should be placed? It is also easy to calculate.

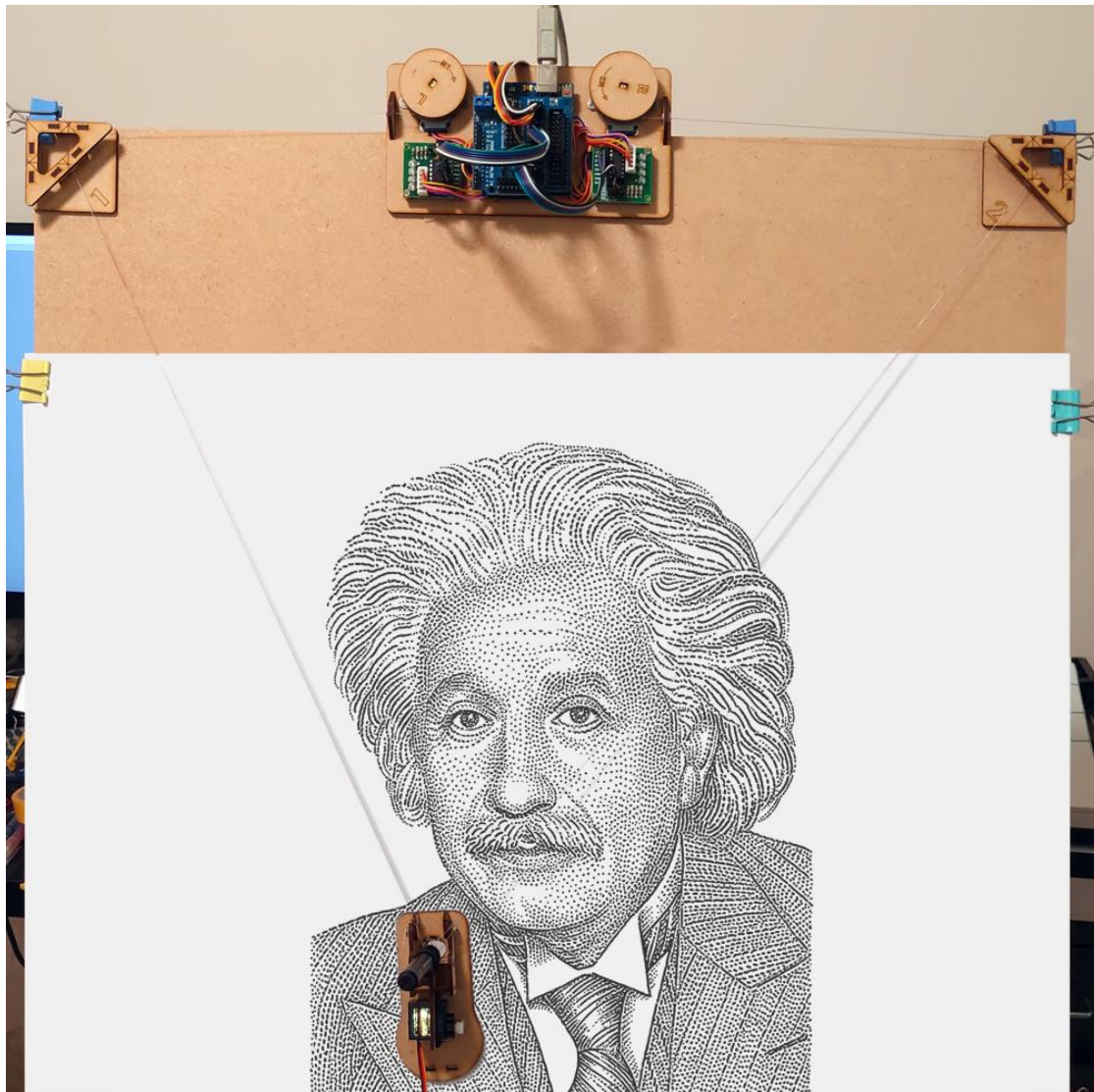


Yizhi AB , CD The length of AD , BD ? If you forgot, please find one 14 Sui Sao Nian asked. Because I only remember that the art class was robbed by the math teacher, and I forgot what I said in the class. Sao Nian told me, $AD = \sqrt{2 + 2}$ Pythagorean theorem was learned in elementary school, and he soon forgot.



From D move to D ' Location, just need to calculate AD with AD ' The difference, BD with BD ' The difference, look at how many lines are put, how many lines are received, and calculate whether the motor should be forward or reverse OK Too. It's that simple.

Then we just read G-code , Move the pen line by line according to the coordinates, and you can draw the godfather of Marlon Brando in one click.



If you are interested in this stuff, you can search Wall Drawing Machine

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