Automatic weld path detection and G-code generation for welding

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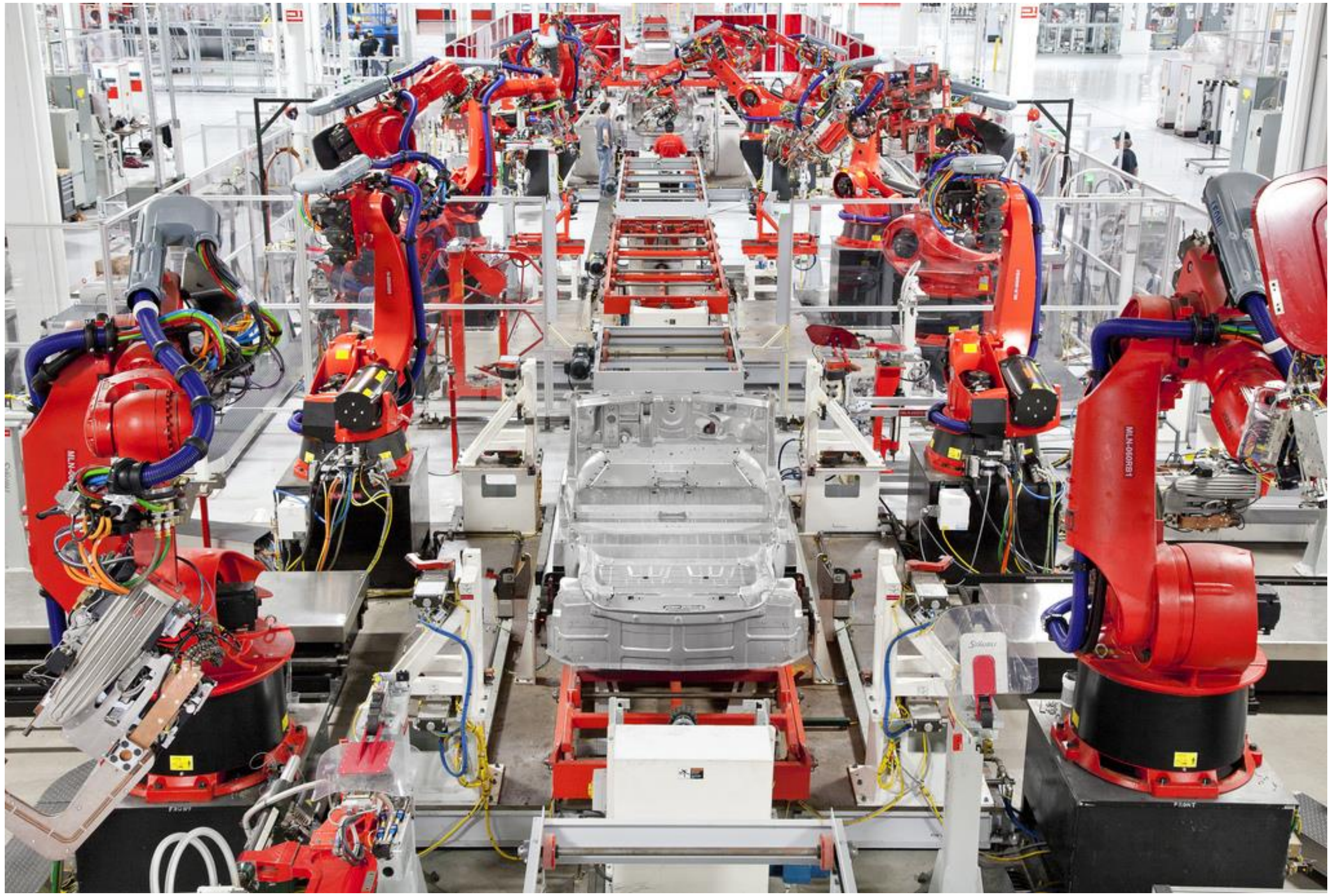
Introduction



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TODAY

Problem Formulation

- In existing automated welding, weld tool path is pre-defined.
- Any change in work-piece is not detected.
- Work-piece must be placed correctly.
- Home position setting is very difficult.
- Need skilled labours for programming and controlling the welding process.

General Objective

- To develop a program to detect the weld path and generate the G-code.
- To prove the concept, fabricate a prototype of 3 axis CNC.

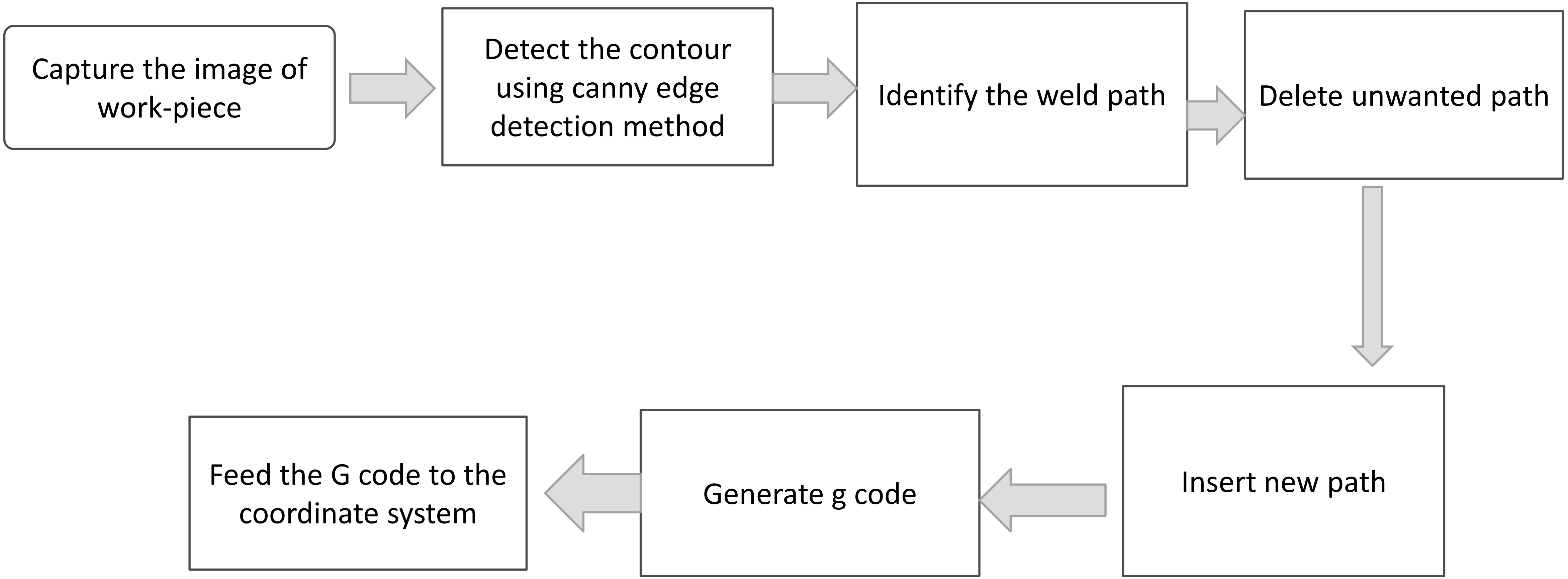
Specific Objective

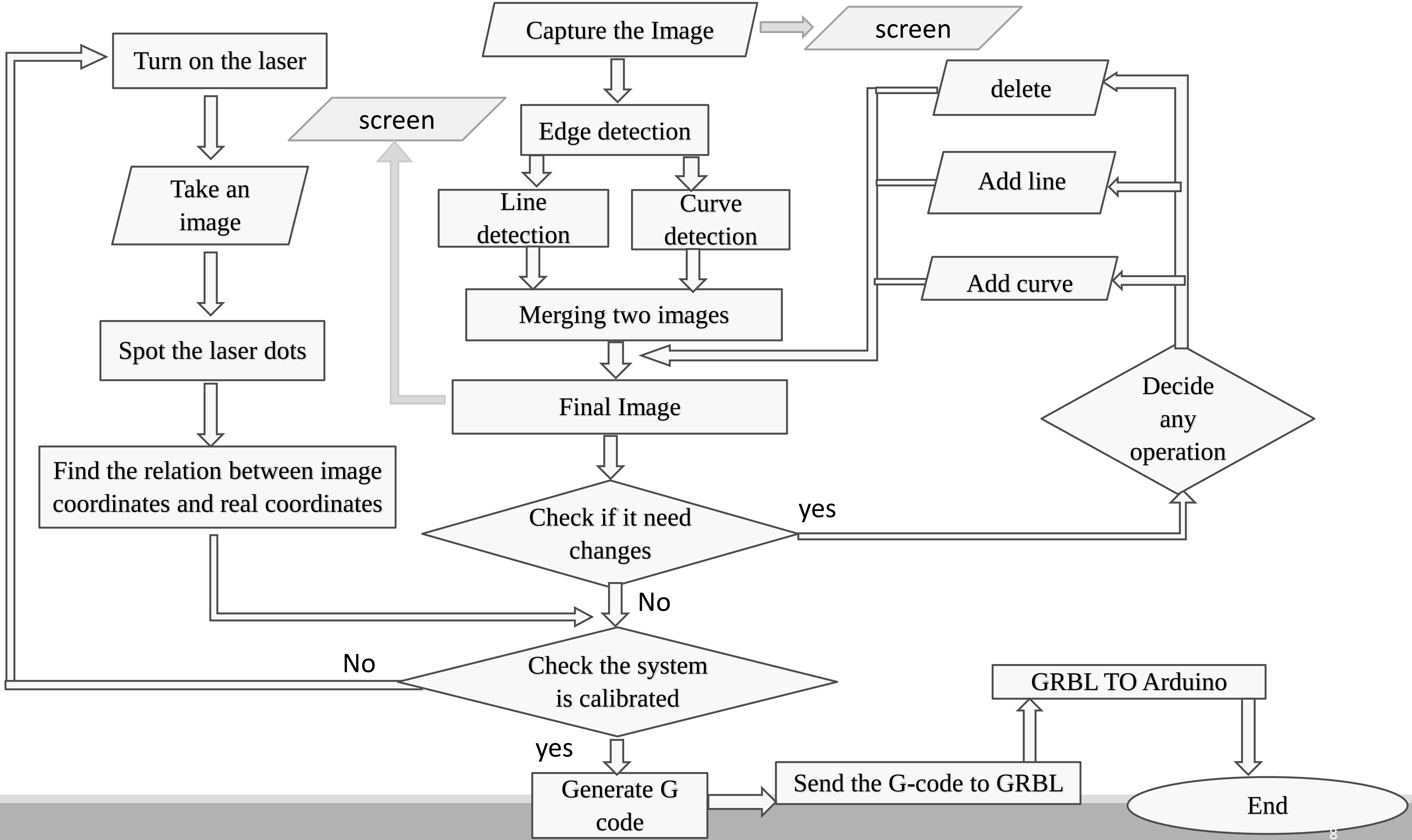
- To identify the best algorithm for edge detection.
- To design the prototype of 3 axis system.
- To fabricate designed prototype system.
- To calibrate and test the prototype.

Methodology

- Literature survey
- Development of the algorithm
- Development of the program for contour detection
- Testing of the program
- Make a CAD model of prototype in Solid Works
- Fabricate a miniature version of 3 axis CNC machine
- Calibration of the system
- Testing in real time

Algorithm

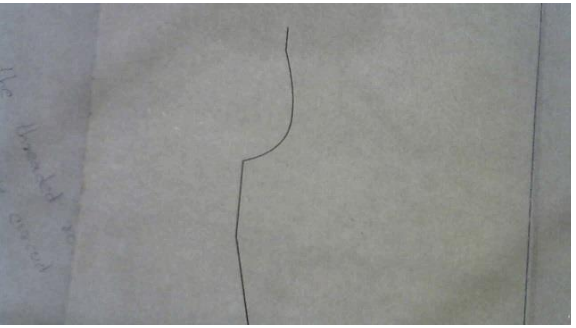

Capture the image of work-piece
Detect the contour using canny edge detection method
Identify the weld path
Delete unwanted path
Insert new path
Generate g code
Feed the G code to the coordinate system


Turn on the laser
Take an image
Spot the laser dots
Find the relation between image coordinates and real coordinates
Capture the Image
screen
Edge detection
Line detection
Curve detection
Merging two images
Final Image
screen
delete
Add line
Add curve
Decide any operation
Check if it need changes
yes
No
Check the system is calibrated
No
yes
Generate G code
Send the G-code to GRBL
GRBL TO Arduino
End

Canny Edge Detection

INPUT IMAGE

SMOOTHING

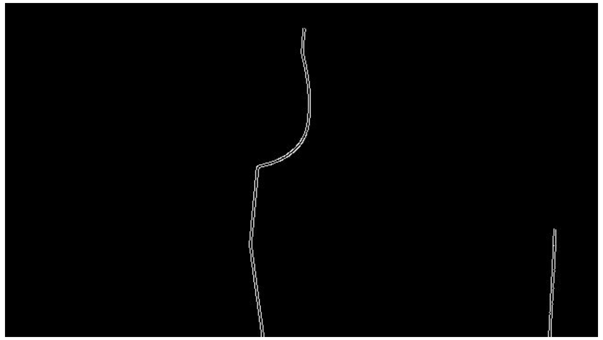


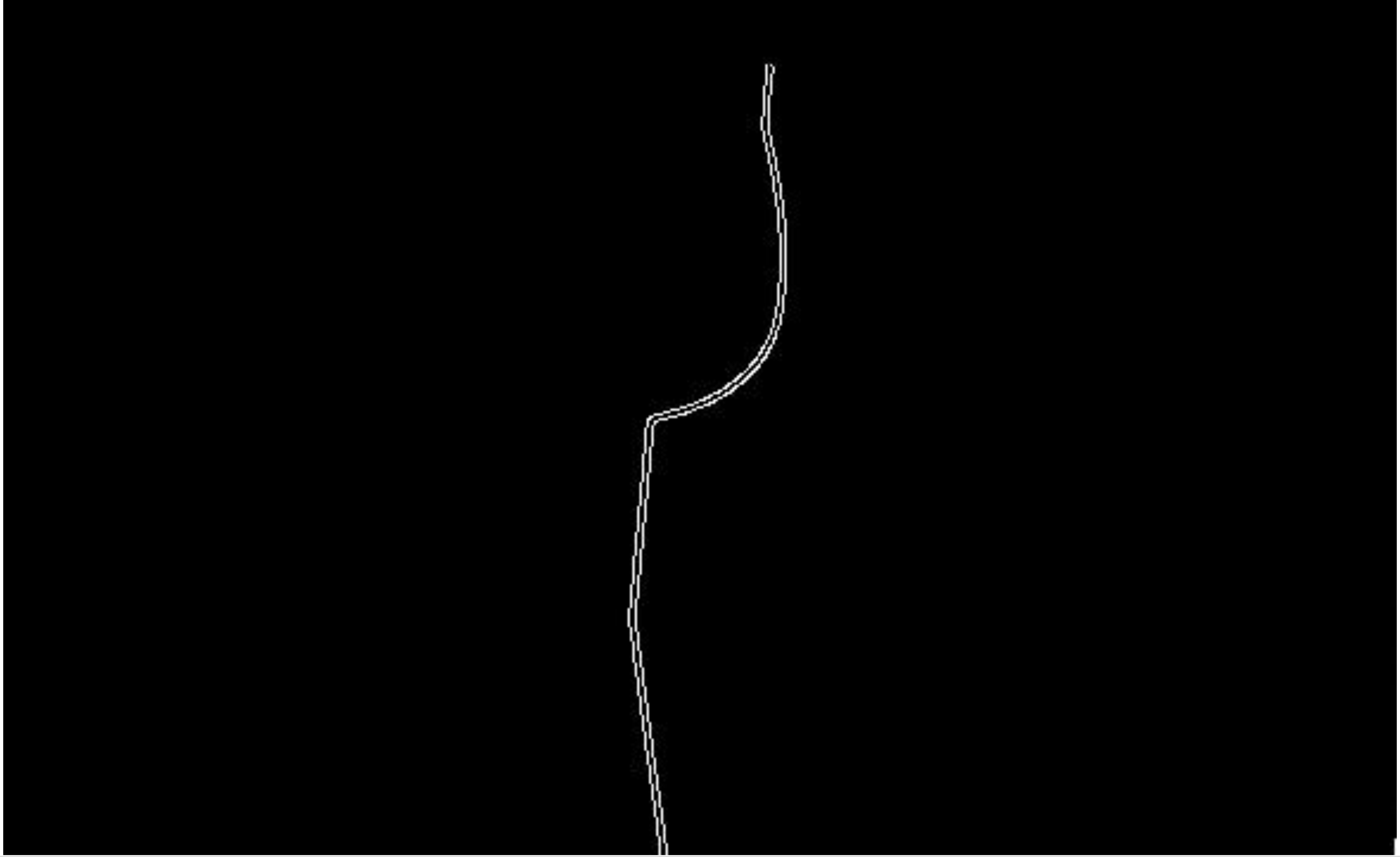
COMPUTE GRADIENTS

NON MAXIMUM SUPRESSION

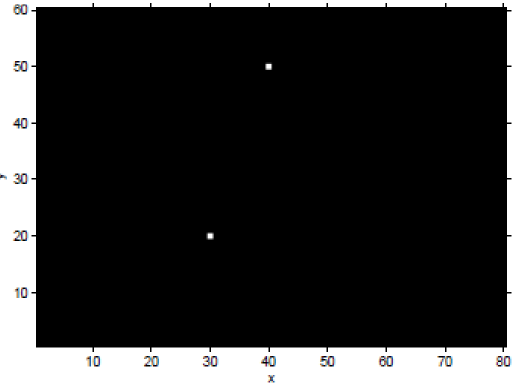
HYSTERESIS THRESHOLDING

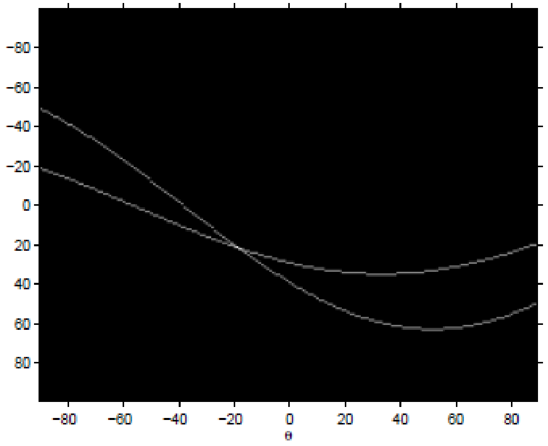
END





Line detection

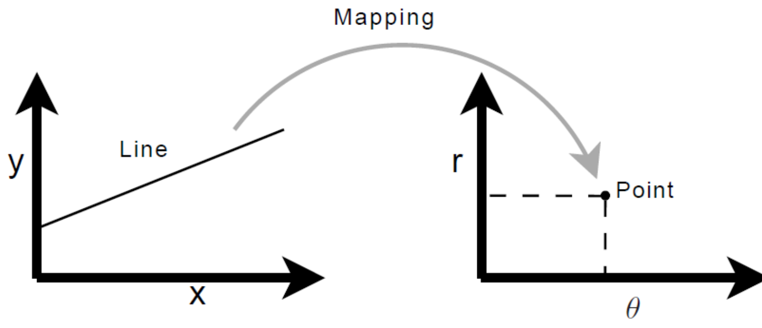




Edge point detection

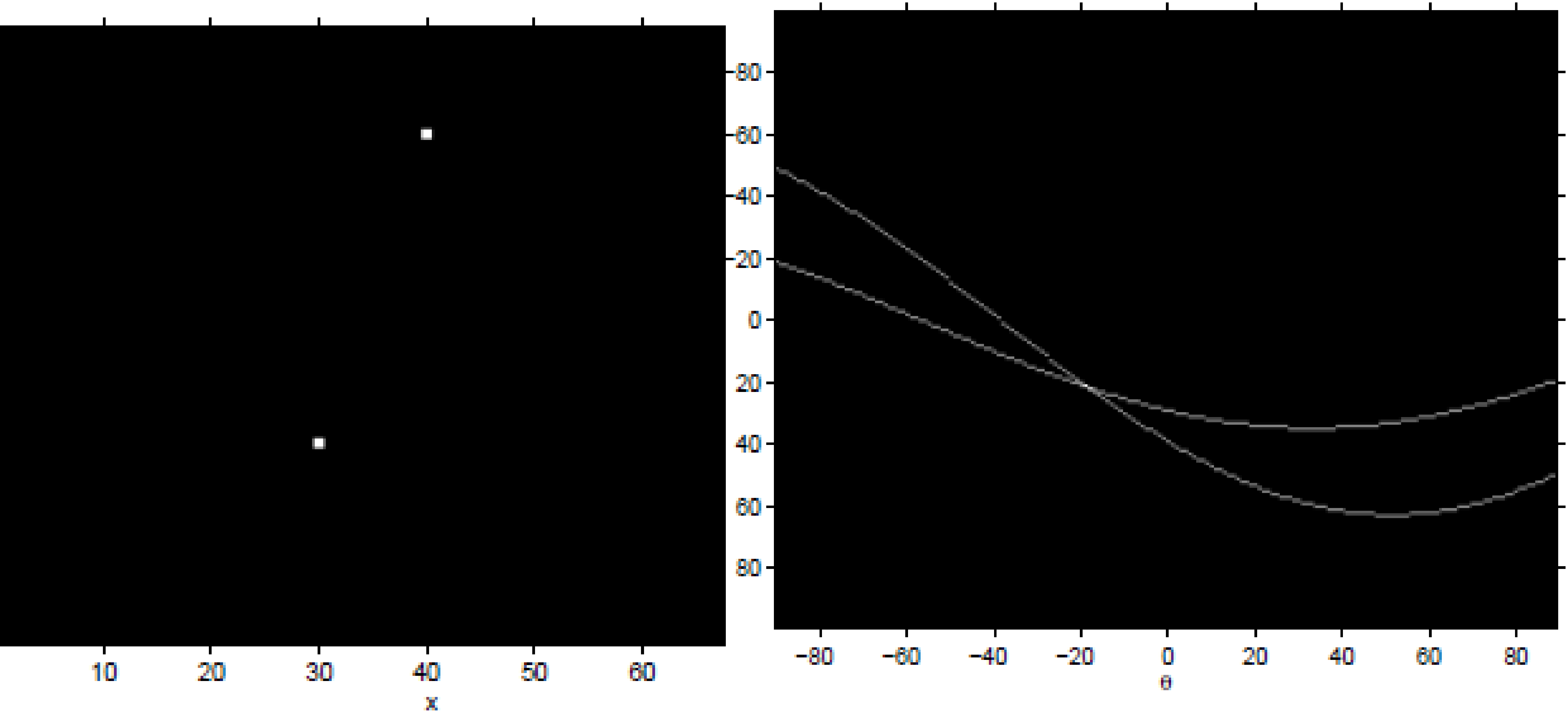
Transfer all the possible lines that can draw by each points

Mapping to Hough space



Detect most overlapped points in Hough space

Convert to straight line


10
20
30
40
50
60
x
80
60
40
20
0
20
40
60
80
−80
−60
−40
−20
0
20
40
60
80
θ

Curve detection

Edge point detection

Transfer all the possible circle that can draw by each points

Mapping to Hough space

Detect most overlapped points in Hough space

Convert to circle

Calibration

Mark two points on the real surface with known distance (use two dot laser emitter with known distance)

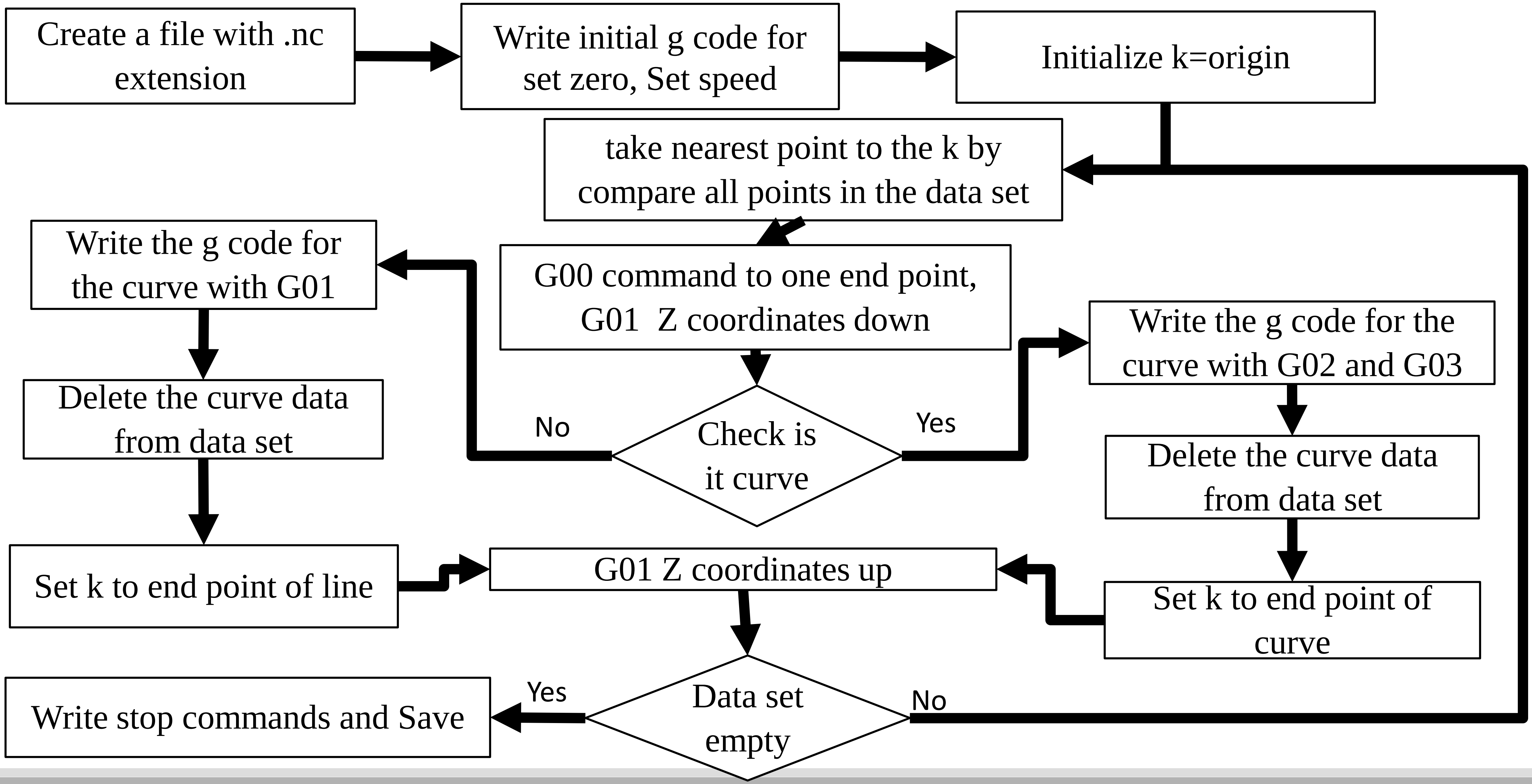
Capture the image with this points

Identify the pixel distance between this points on the image

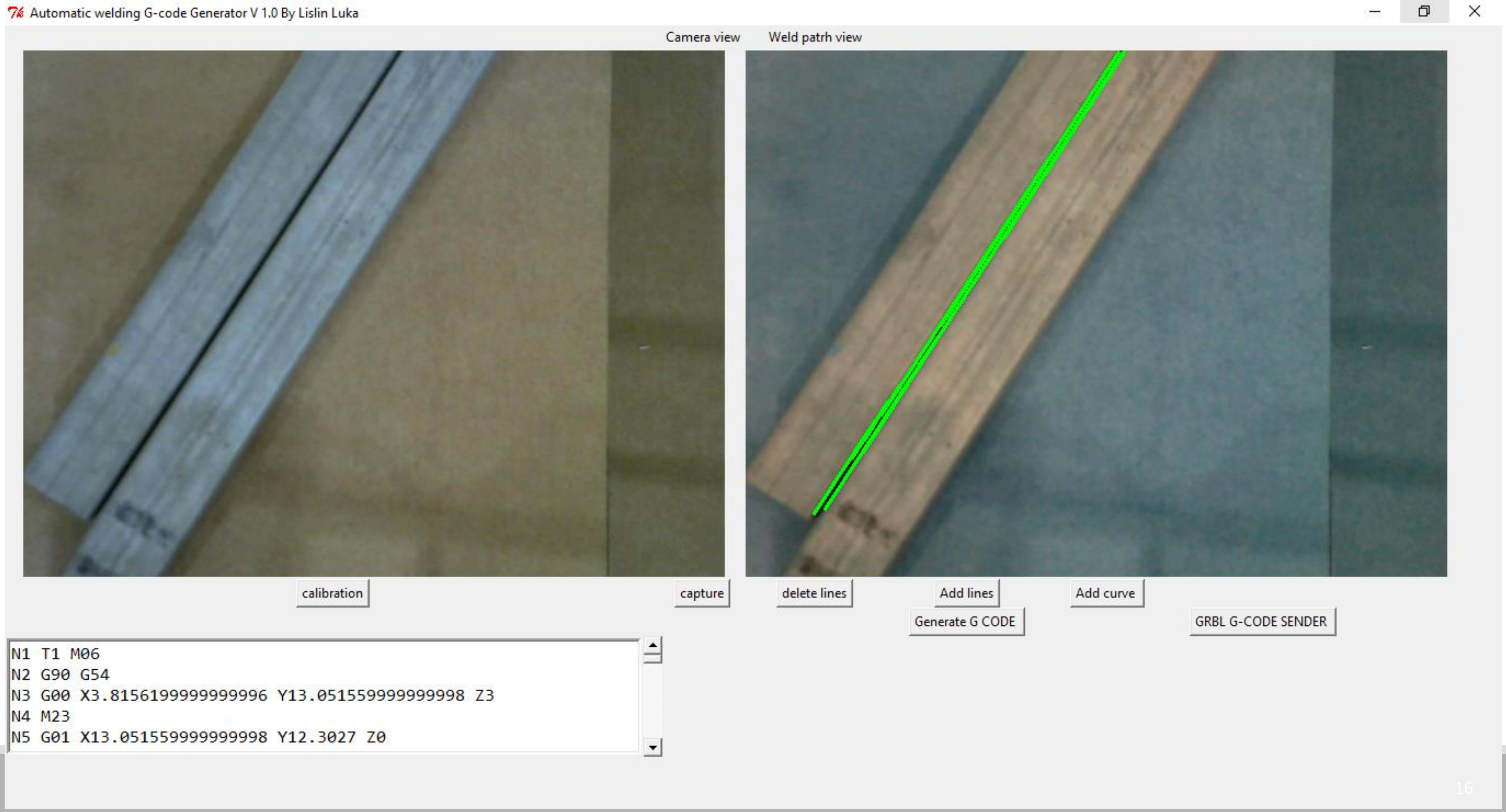
Take the proportion of real distance and pixel distance

Apply this ratio to all pixel address

G code generation algorithm



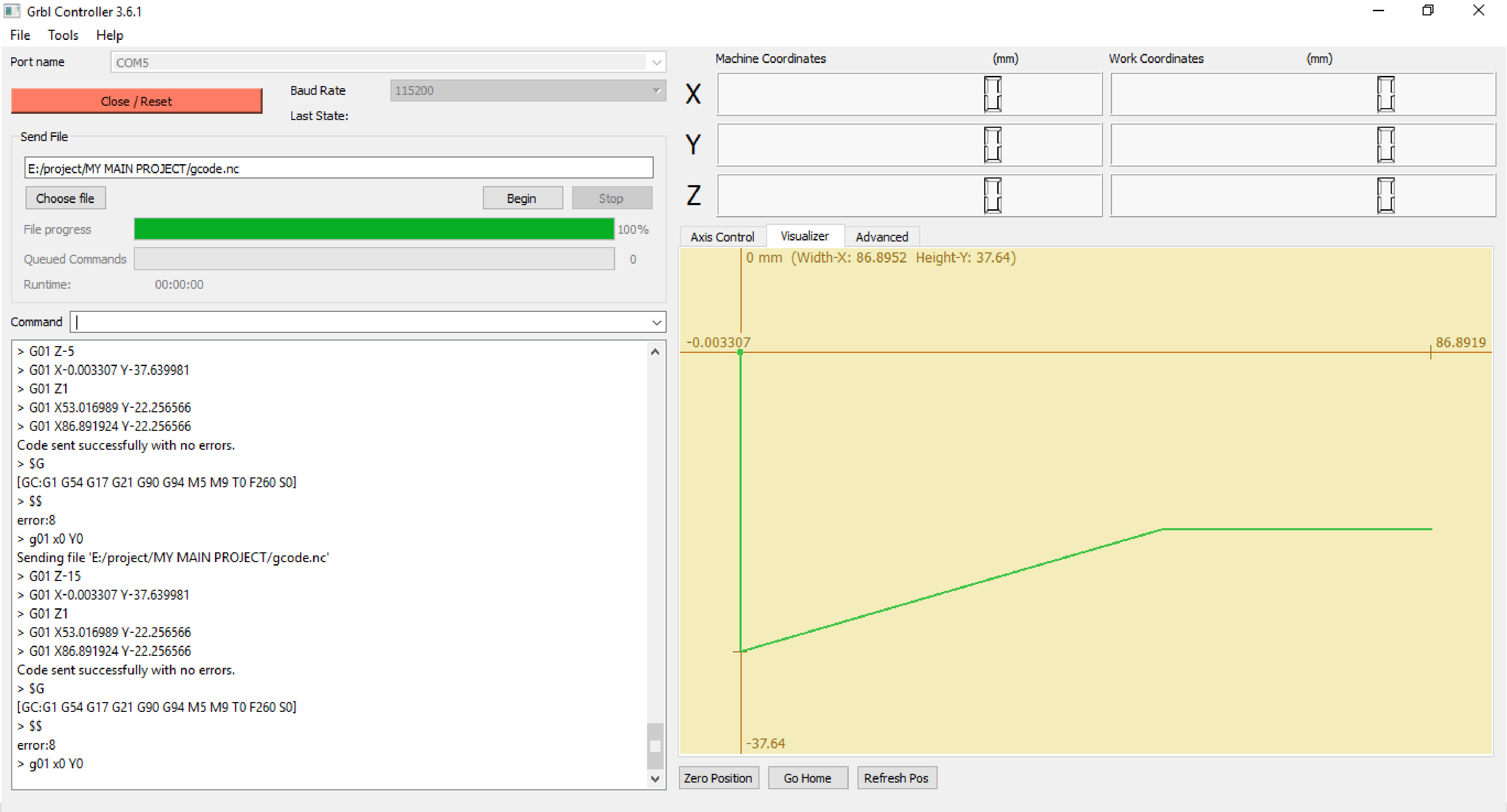
Graphical User Interface



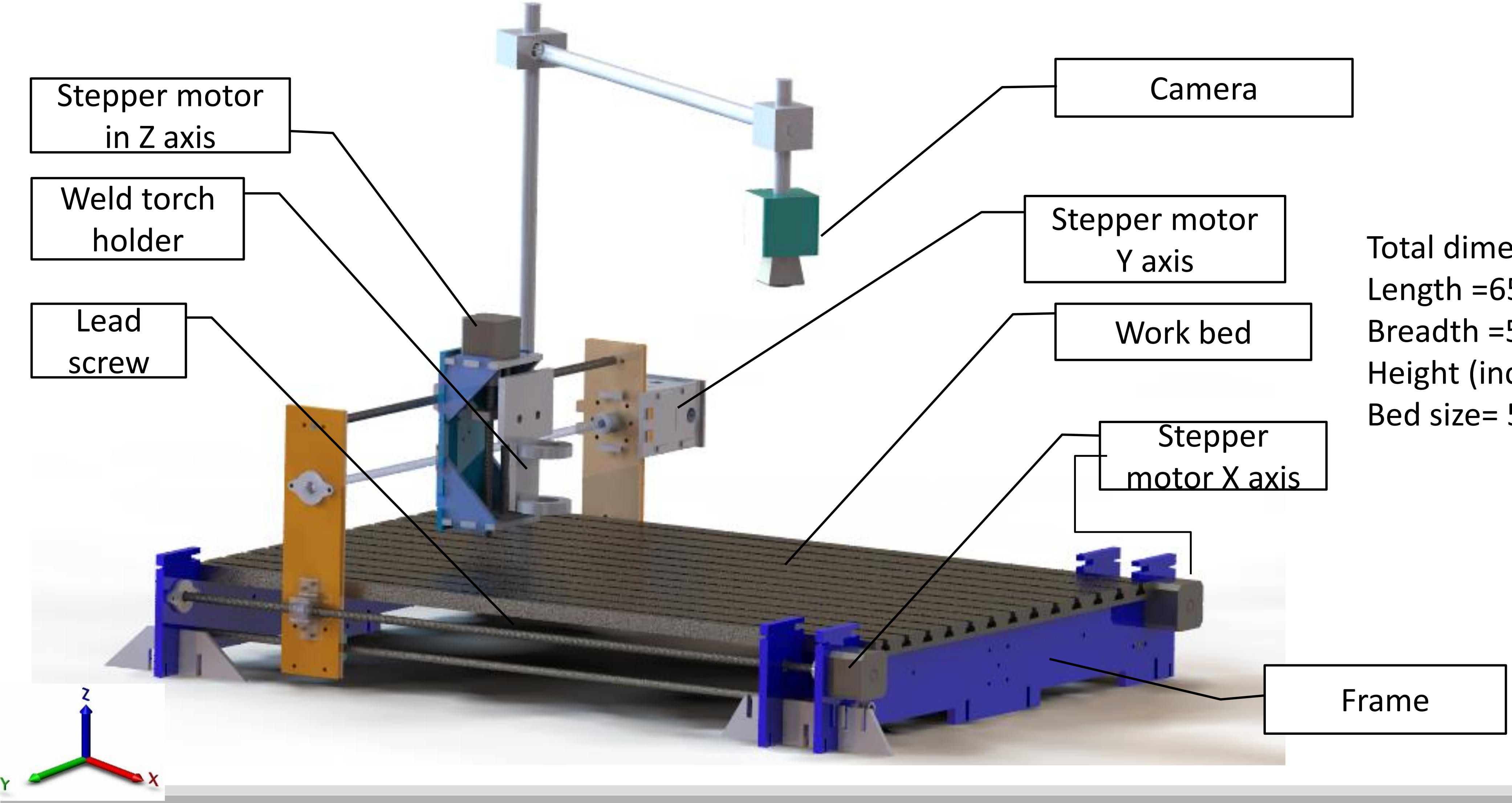
GRBL

- GRBL is a free software.
- It is used for light duty production
- It is Configurable
- It has Real-time Status Reporting
- Can do Multi-Tasking Run-time Commands

GRBL User Interface



CAD model of system

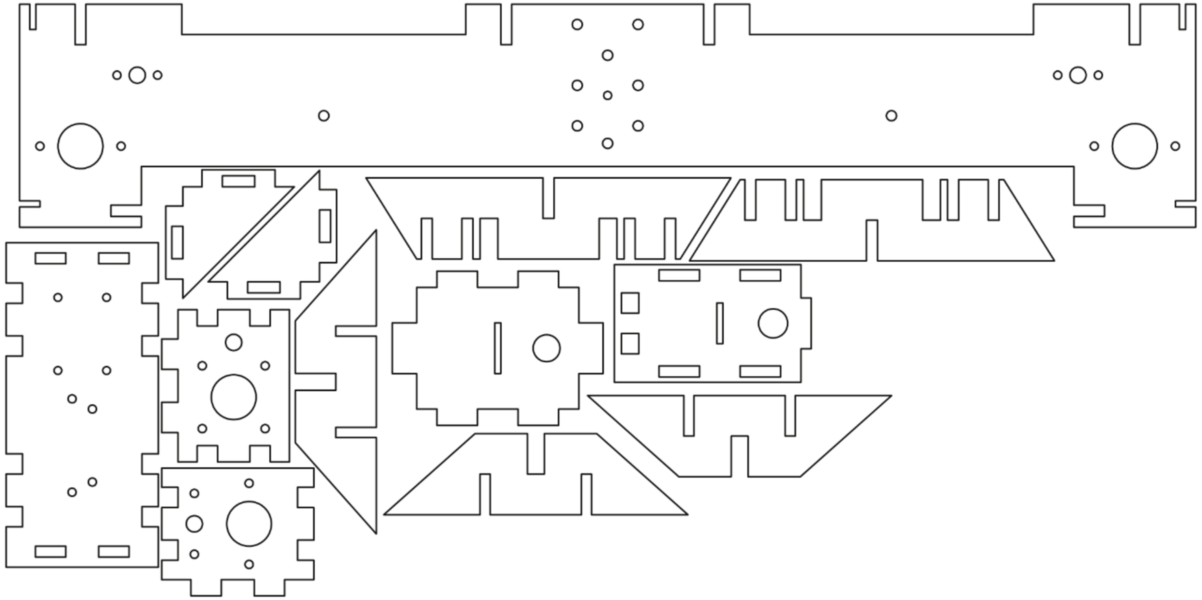


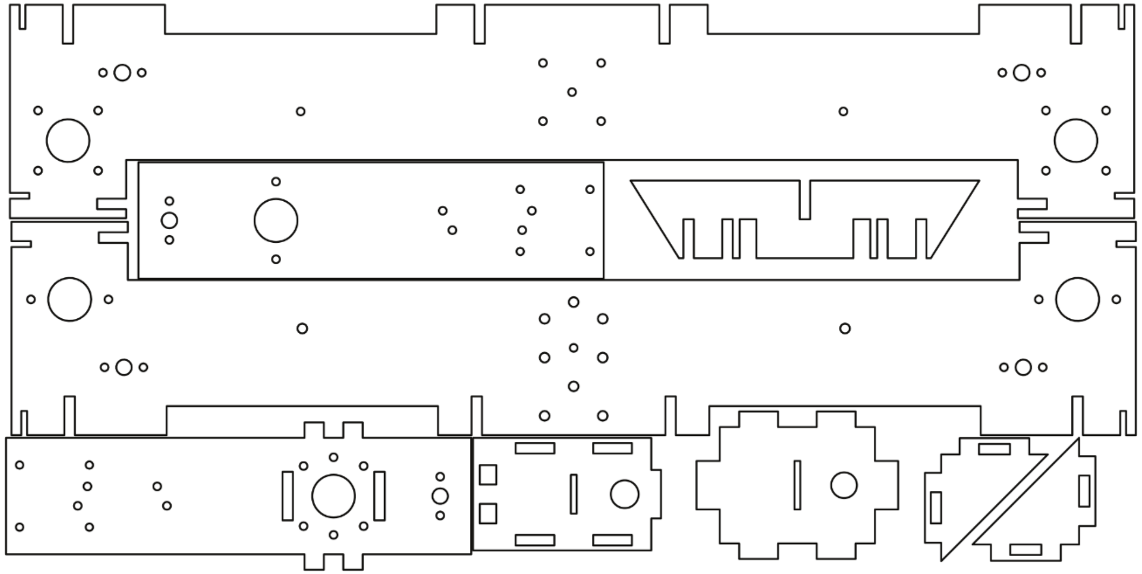
Total dimensions
Length =65cm
Breadth =50cm
Height (including camera)=45cm
Bed size= 55 X 40 cm

List of parts and specification

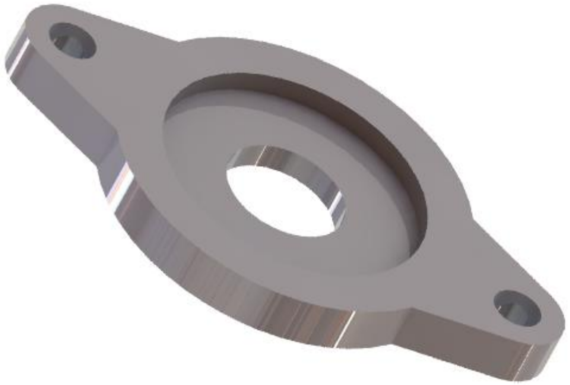
Si no.:	Name	material	SPECIFICATION	quantity
1	Frame	acrylic	8mm thickness	45 m^2 (2 sheets)
2	Guide way	steel	8 mm dia	3m
3	Lead screw	steel	8 mm dia, 1mm pitch	3m
4	Linear bearing	Pressed steel	8mm inner dia	4
5	Radial Ball bearing	Pressed steel	8 mm inner dia	5
6	Flexible coupler	Aluminum	5 to 8mm dia	4
7	Other parts made in 3D printer	PLA		
8	Nut	Steel	8mm inner dia	4

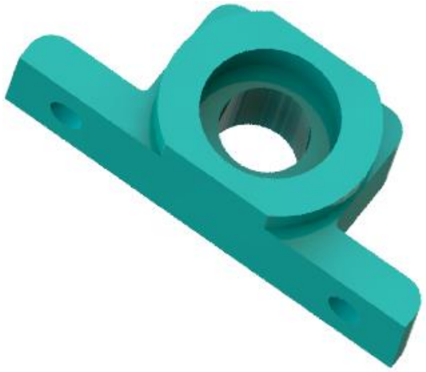
Laser cut drawings



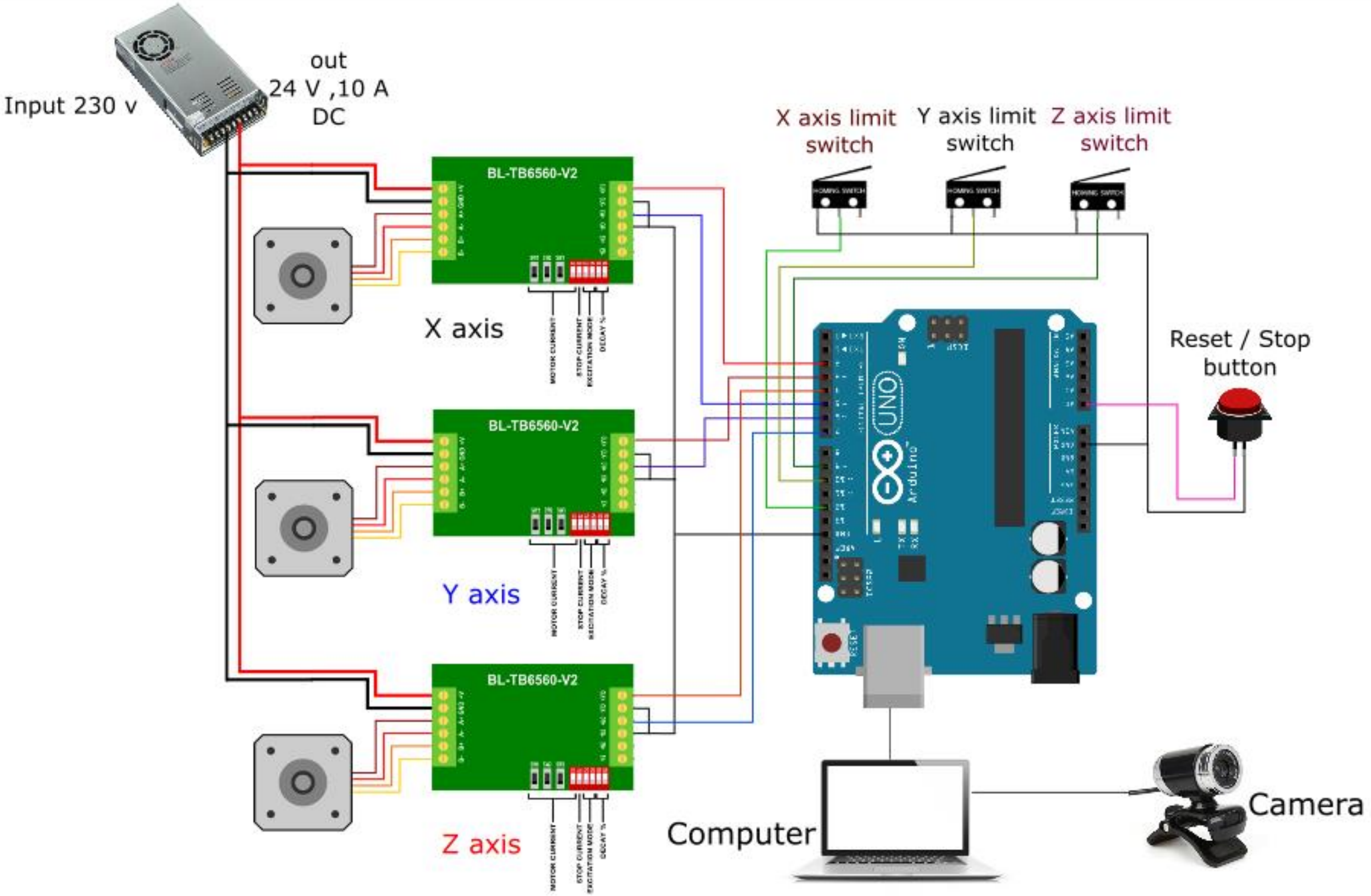


3D Printed parts models





Electrical Circuit



List of electric component with specification

Si No.:	name	specification	qty
1	Arduino	UNO	1
2	Stepper motor	Nema 17, 4.2 kg-cm, bipolar	4
3	Motor driver(TB6560)	24 V 3A 1/8 microstepping	4
4	SMPS	24 V 10 A	1
5	Limit switch	SPST	3
6	Camera	5 Mega Pixel	1

Parts specification

ARDUINO UNO REV3

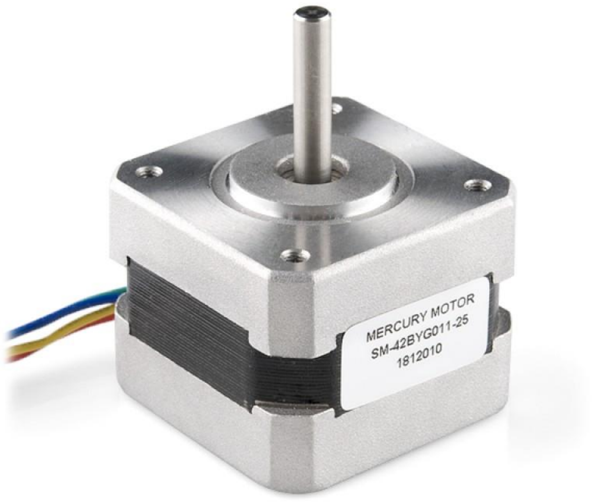
- Microcontroller: ATmega328
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limits): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 40 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328)
- EEPROM: 1 KB (ATmega328)
- Clock Speed: 16 MHz

Parts specification

Logitech c310 web camera

- resolution 1280 X 720 pixels
- 5 Mega pixel
- Hi-Speed USB 2.0 certified

Stepper Motor NEMA 17

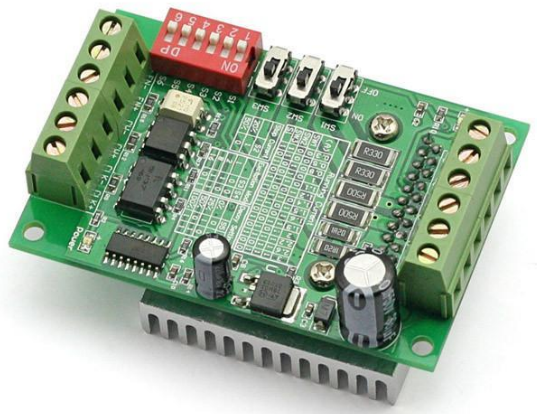


- 1.5A to 1.8A current per phase
- Bipolar
- 12 volts
- 3 to 8 mH inductance per phase
- 44 N·cm (62oz·in, 4.5kg·cm) or more holding torque
- 1.8 degrees per step (200 steps/rev respectively)

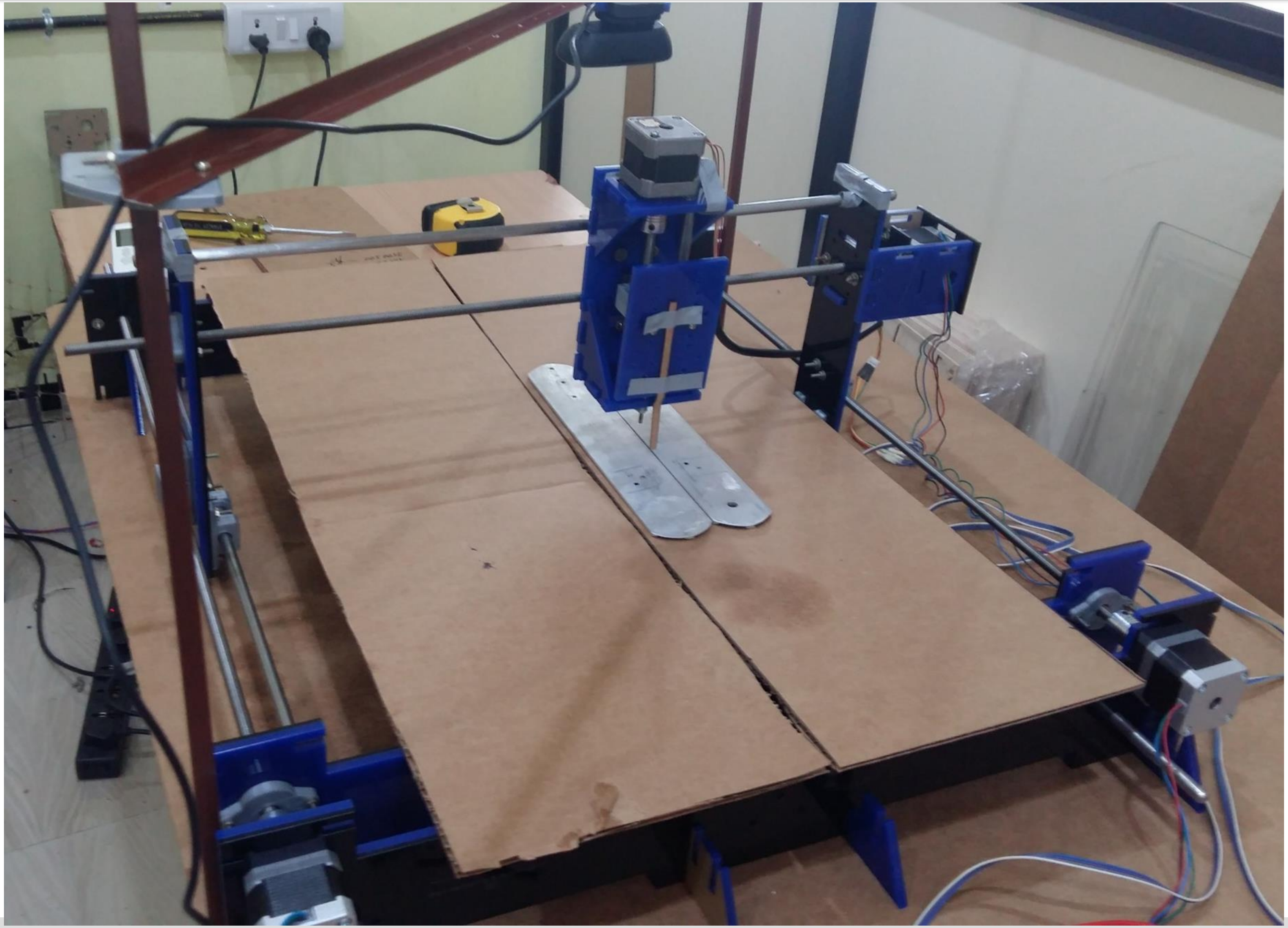
Parts specification

Motor Driver TB6560

- Low cost and good high-speed torque
- Supply voltage up to +32 VDC
- Output current up to 3.0A
- Pulse frequency up to 20 KHz
- Suitable for 2-phase and 4-phase motors
- Over-voltage and short-circuit protection



Prototype



Specifications of prototype

Lead screw pitch = 1mm

Stepper motor degree per pulse =1.8^{o}

Number of steps for one rotation of lead screw $= {}^{360}/_{1.8} = 200$

So minimum linear movement can achieve by the prototype $= {}^{1mm}/_{200} = .005mm$

Maximum speed of travel = 10 mm/sec

Data set in GRBL software

Acceleration linear movement = 50 mm/s^{2}

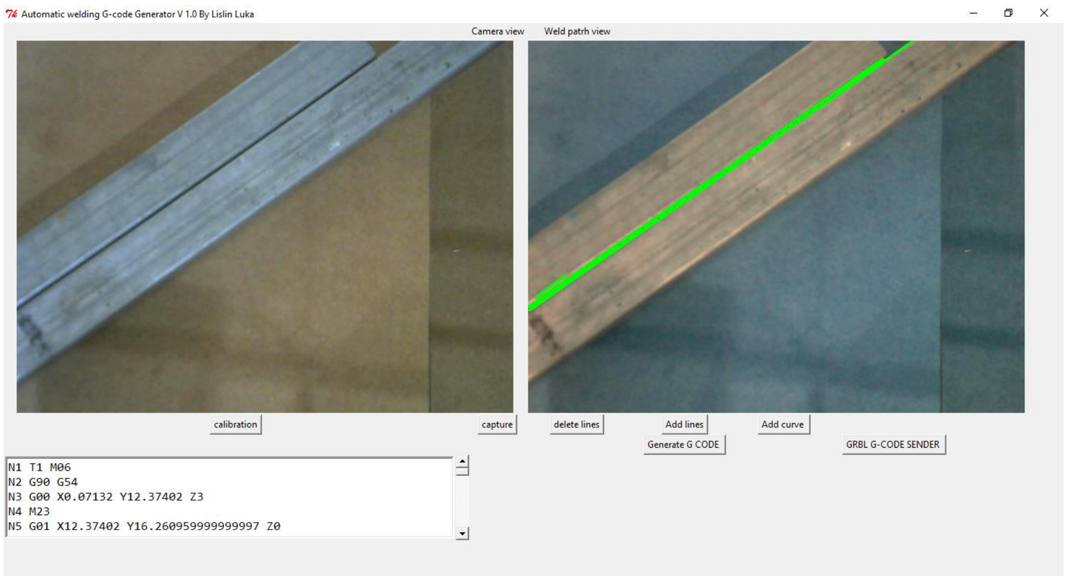
Step per mm in x axis =200 steps

Step per mm in y axis =200 steps

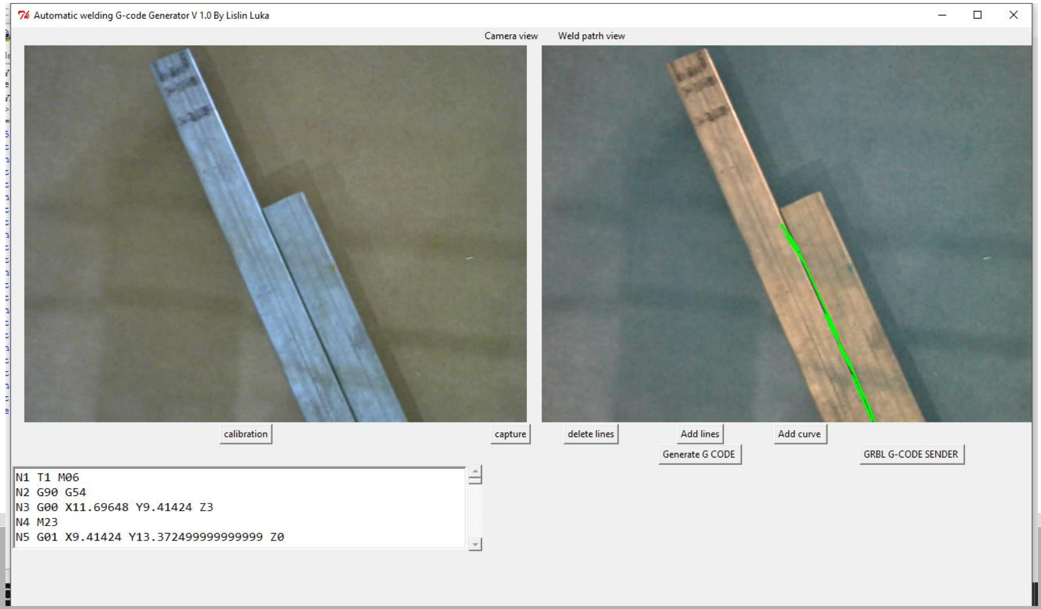
Step per mm in z axis =200 steps

Results

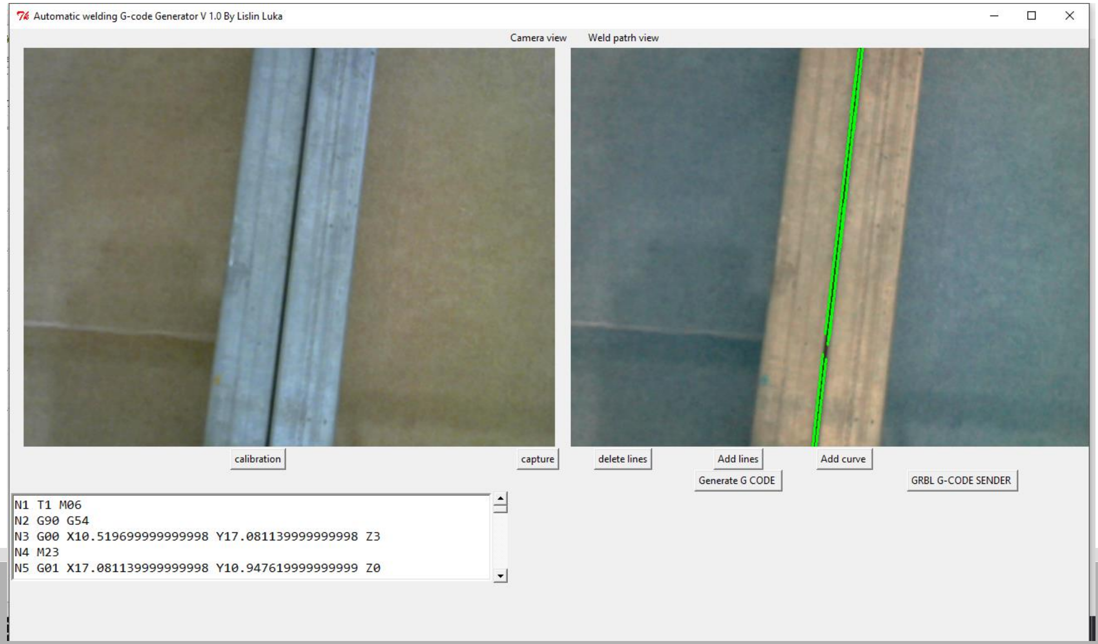
Automatic welding G-code Generator V 1.0 By Lislin Luka
Camera view
Weld patrh view
calibration
capture
delete lines
Add lines
Add curve
Generate G CODE
GRBL G-CODE SENDER
N1 T1 M06
N2 G90 G54
N3 G00 X3.8156199999999996 Y13.051559999999998 Z3
N4 M23
N5 G01 X13.051559999999998 Y12.3027 Z0



Automatic welding G-code Generator V 1.0 By Lislin Luka
Camera view
Weld patrh view
calibration
capture
delete lines
Add lines
Add curve
Generate G CODE
GRBL G-CODE SENDER
N1 T1 M06
N2 G90 G54
N3 G00 X0.07132 Y12.37402 Z3
N4 M23
N5 G01 X12.37402 Y16.260959999999997 Z0



Automatic welding G-code Generator V 1.0 By Lislin Luka
Camera view
Weld patrh view
calibration
capture
delete lines
Add lines
Add curve
Generate G CODE
GRBL G-CODE SENDER
N1 T1 M06
N2 G90 G54
N3 G00 X11.69648 Y9.41424 Z3
N4 M23
N5 G01 X9.41424 Y13.372499999999999 Z0



Automatic welding G-code Generator V 1.0 By Lislin Luka
Camera view
Weld patrh view
calibration
capture
delete lines
Add lines
Add curve
Generate G CODE
GRBL G-CODE SENDER
N1 T1 M06
N2 G90 G54
N3 G00 X10.519699999999998 Y17.081139999999998 Z3
N4 M23
N5 G01 X17.081139999999998 Y10.947619999999999 Z0


Automatic welding G-code Generator V 1.0 By Lislin Luka
Camera view
Weld patrh view
calibration
capture
delete lines
Add lines
Add curve
Generate G CODE
GRBL G-CODE SENDER
N1 T1 M06
N2 G90 G54
N3 G00 X13.515139999999999 Y10.05612 Z3
N4 M23
N5 G01 X10.05612 Y17.580379999999998 Z0

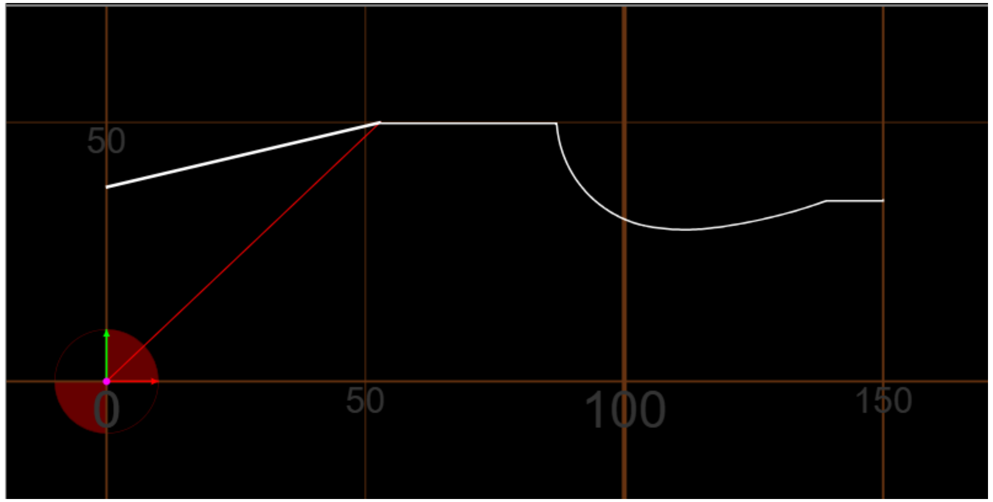

Automatic welding G-code Generator V 1.0 By Lislin Luka
Camera view
Weld patrh view
calibration
capture
delete lines
Add lines
Add curve
Generate G CODE
GRBL G-CODE SENDER
N1 T1 M06
N2 G90 G54
N3 G00 X8.308779999999999 Y12.26704 Z3
N4 M23
N5 G01 X12.26704 Y8.594059999999999 Z0


Automatic welding G-code Generator V 1.0 By Lislin Luka
Camera view
Weld patrh view
calibration
capture
delete lines
Add lines
Add curve
Generate G CODE
GRBL G-CODE SENDER
N1 T1 M06
N2 G90 G54
N3 G00 X9.84216 Y5.6699399999999995 Z3
N4 M23
N5 G01 X5.6699399999999995 Y11.83912 Z0

Generated G code

```
G00 Z5.000000
G00 X52.983365 Y50.14374
G01 Z-1.000000 F100.0(Penetrate)
G01 X-0.003307 Y37.639981 Z-1.000000 F400.000000
G01 X0.062839 Y37.360516 Z-1.000000
G01 X53.016989 Y49.856566 Z-1.000000
G01 X86.891924 Y49.856566 Z-1.000000
G02 X87.019383 Y49.044178 Z-1.000000 I-7.403867 J-1.577811
G03 X104.976194 Y29.858477 Z-1.000000 I21.569975 J2.192199
G03 X116.533296 Y29.565304 Z-1.000000 I6.803391 J40.253367
G03 X127.399633 Y31.453142 Z-1.000000 I-11.616101 J99.078953
G03 X138.951114 Y34.830004 Z-1.000000 I-23.770492 J102.759426
G03 X139.023108 Y34.856344 Z-1.000000 I-1.386780 J3.901871
G01 X150.000008 Y34.856344 Z-1.000000
G01 X150.000008 Y35.143528 Z-1.000000
```

G code simulation



Working video

CONCLUSIONS

- Developed a program for automatic detection of weld path and generation of G-code.
- With the developed graphical user interface, user can easily operate the system.
- Using this system weld tool path generated automatically.
- Error due to misplaced work-piece can be avoided.
- In complicated weld path, G code is generated easily.
- Using the fabricated prototype, the developed system is tested successfully.

Limitations

- The camera resolution and focal length will decide the area of workspace
- Camera has to be calibrated again, if its position is altered
- G code generated only for two dimensional welding

Future work

- Develop a solution for generate G code in three dimensional welding.

- Incorporate the developed system with robotic arm.

- Including artificial intelligent to track the weld path more accurately.

Reference

- Rashmi, Mukesh Kumar, and Rohini Saxena - ALGORITHM AND TECHNIQUE ON VARIOUS EDGE DETECTION: A SURVEY - Signal & Image Processing : An International Journal (SIPIJ) Vol.4, No.3, June 2013
- Min-Goo Kang , Joan-Hong Kim , Young-Jun Park , Gap-Joo Woo - LASER VISION SYSTEM FOR AUTOMATIC SEAM TRACKING OF STAINLESS STEEL PIPE WELDING MACHINE - International Conference on Control, Automation and Systems 2007 Oct. 17-20, 2007 in COEX, Seoul, Korea
- Akhil P, Abhijith C. R, Bijoy A Jose - INTERFACING A COMPUTER AIDED DESIGN TOOL WITH A MULTI-FUNCTION NUMERICAL MACHINE - 2016 Sixth International Symposium on Embedded Computing and System Design (ISED)
- AMRUTA L KABADE, Dr.V.G. Sangam - CANNY EDGE DETECTION ALGORITHM - International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE) Volume 5, Issue 5, May 2016
- Joko Siswantoro, Anton Satria Prabuwono, and Azizi Abdullah- REAL WORLD COORDINATE FROM IMAGE COORDINATE USING SINGLE CALIBRATED CAMERA BASED ON ANALYTIC GEOMETRY - Springer-Verlag Berlin Heidelberg 2013
- Ai-min Li, Chuan-hui Zhang, Hai-lin Li, Zhi-yang Xu, Xiao-hui Chen, Guang-le Qin, Sheng-wei Ye -DESIGN OF AUTOMATIC WELDING MACHINE BASED ON PLC - 2011 Fourth International Conference on Intelligent Computation Technology and Automation
- Min-Goo Kangl , Joan-Hong Kim , Young-Jun Park , Gap-Joo Woo - LASER VISION SYSTEM FOR AUTOMATIC SEAM TRACKING OF STAINLESS STEEL PIPE WELDING MACHINE - International Conference on Control, Automation and Systems 2007 Oct. 17-20, 2007 in COEX, Seoul, Korea

THANK YOU

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Motor torque calculation

For Y axis movement

total torque = torque due to friction +torque due to acceleration or inertia =0.152 Nm

torque to overcome friction =(μ×W)/(2π×p)

=.046 Nm

μ= coefficient of friction = 0.15

W= Load = 2 kg

P= pitch in mm = .1

torque to overcome inertia or acceleration torque= $J_{total} \times \alpha$= 0.106 Nm

J_{total} $=$ J due to motor+ J due to load

$J_{load} = J_{L\,linear} + J_{L\,rotary}$

$$J_{L\,linear} = \left(\frac{W_L + W_T}{g}\right) \times \left(\frac{1}{2\pi \times P}\right)^2$$

$$J_{L\,rotary} = \frac{\pi \times L \times \rho \times r^4}{2g}$$

$W_L + W_T =$ Total weight = W= 2kg

$g = acceleration\ due\ to\ \ gravity$

ρ = density of rotating object = 7.81 kg/m^3

r $=$ radius of rotating object =.008m

L $=$ Length of rotating object = .6m

α $=$ angular acceleration =8 rev/s^2