# Budget 3D Scanner Project

(Redistribution Edition - Open Source Project)
Hardware & Arduino Programming: Toby
Post-processing & Optimization: Andy

# Introduction

- 3D Scanners are kind of expensive right now but it has a wide range of application
- We want to make a low cost 3D scanner with ToF Sensor and two stepper motors as **Proof of Concept**
- Aim as create somewhat observable 3D models from one single sensor by converting the sensor data into point clouds that construct the 3D model

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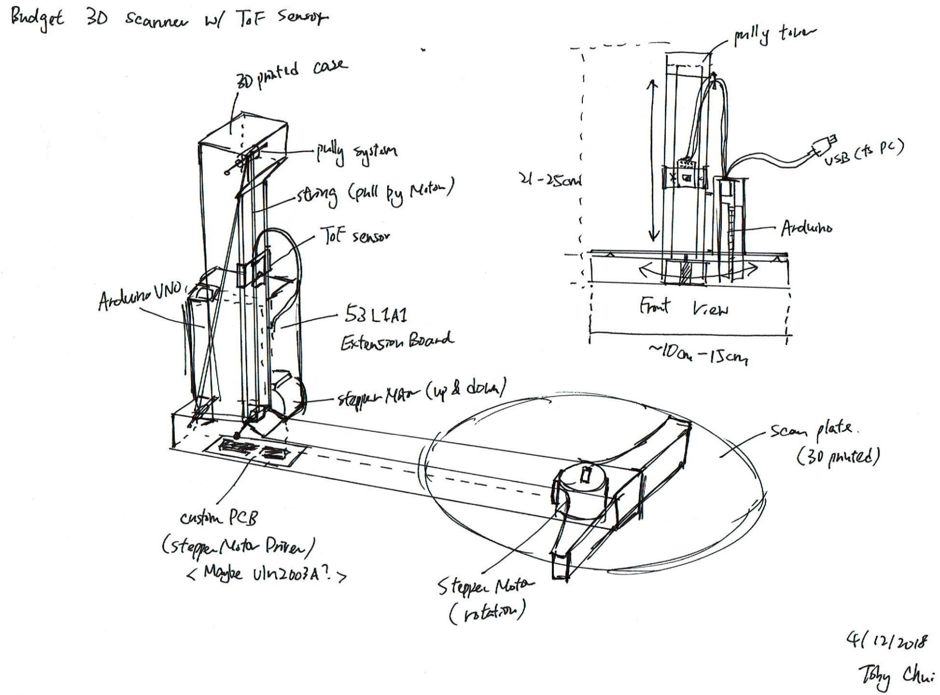
# Design Sketch

Draft design of the scanner, designed to be completely 3D printable and cheap to build.

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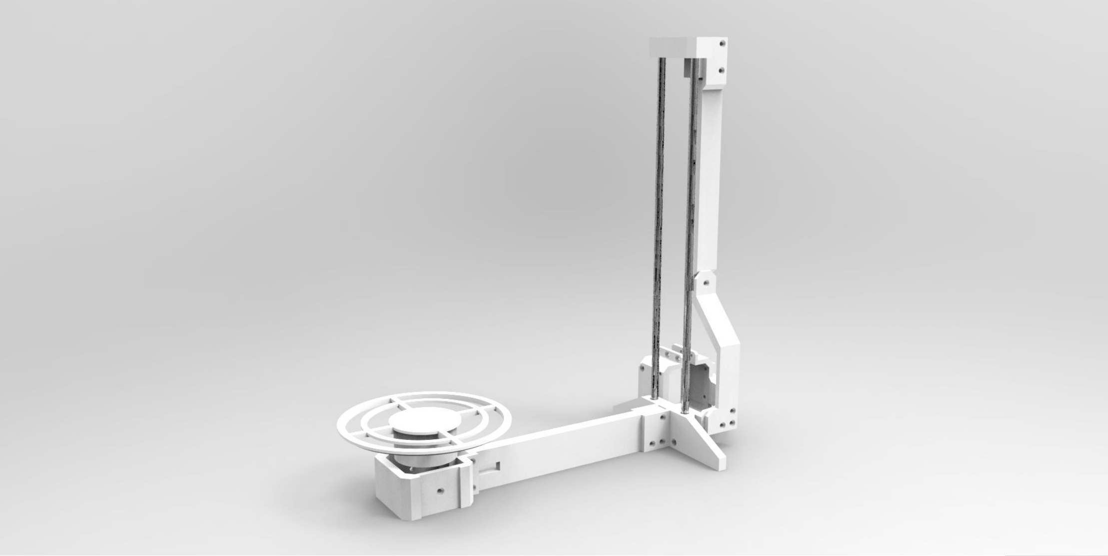
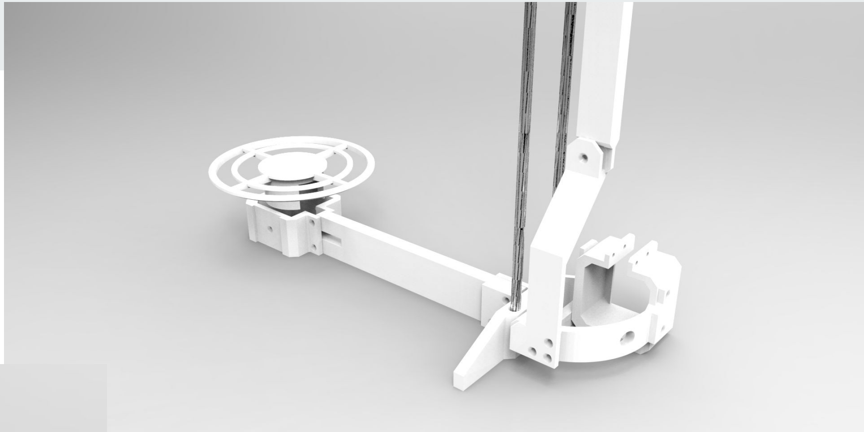
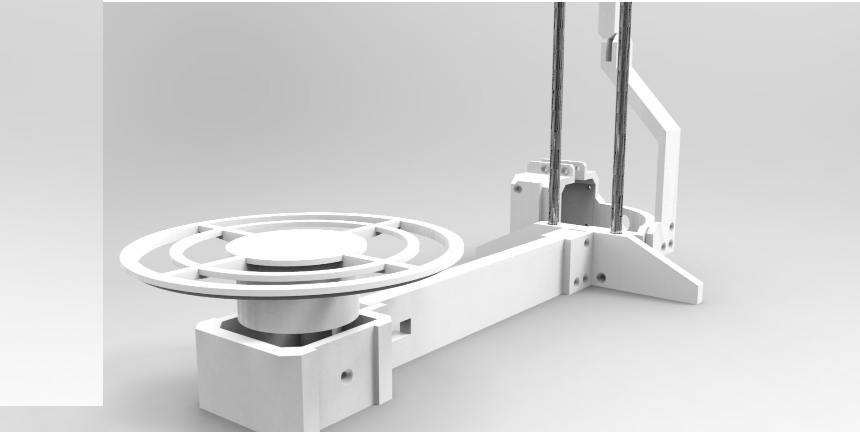
# 3D modeling (and render)







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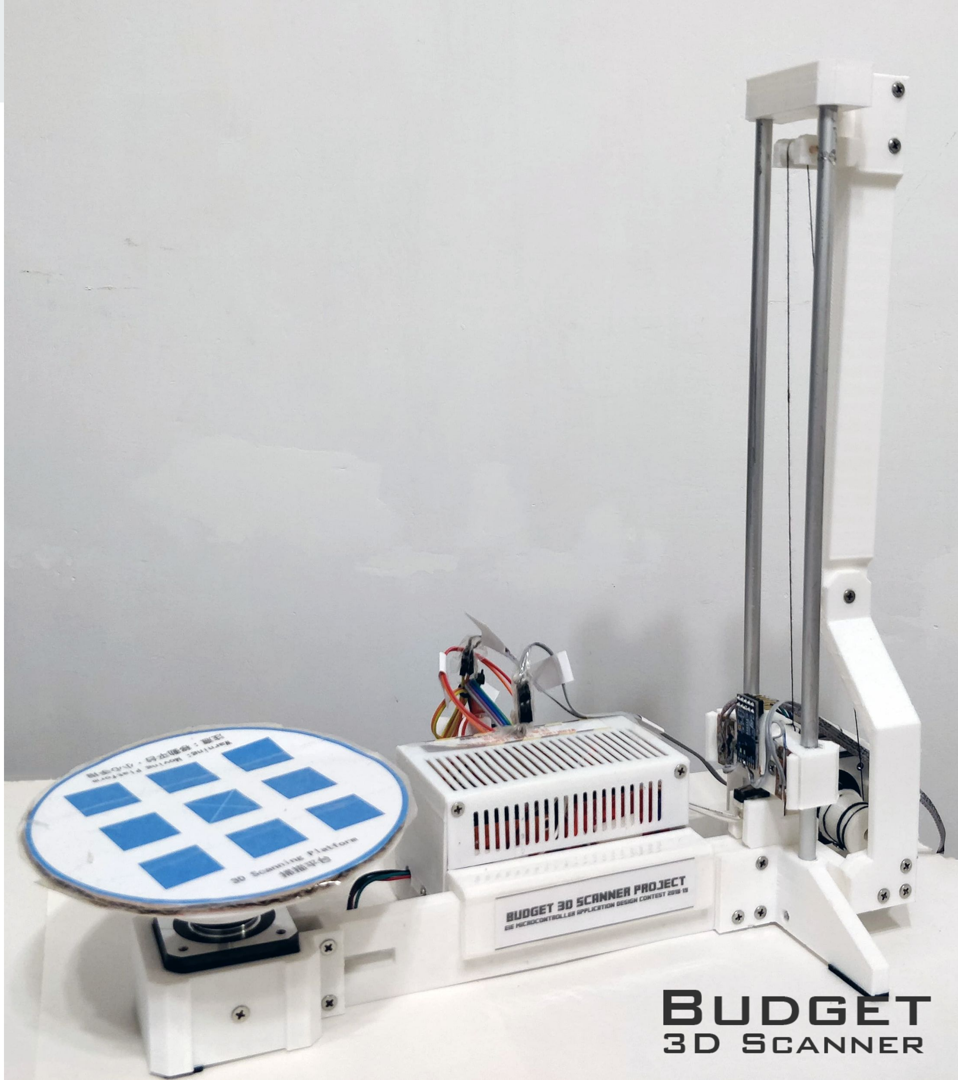
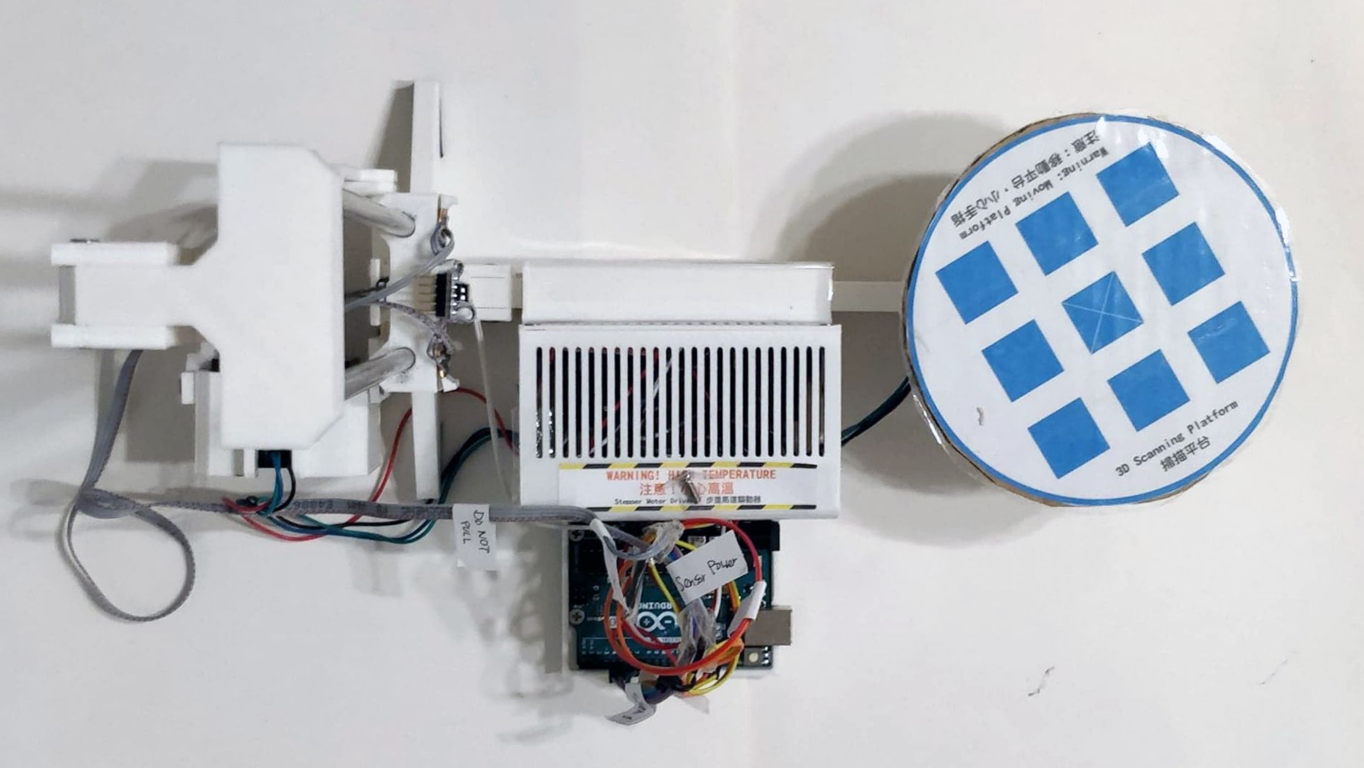
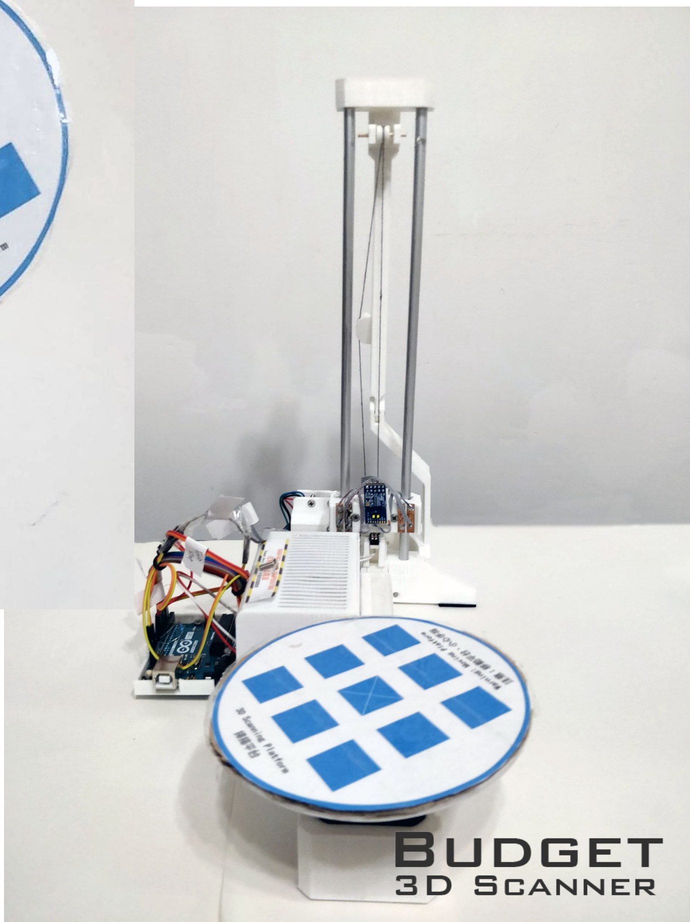
# Final Product (Scanner)

Specification:

**VL53L1X ToF Sensor**
**(SHARP GP2D12F)**
**Arduino UNO**
**2.8V Stepper Motor x2**
**Many 3D Printed Parts**





Top View and Front View

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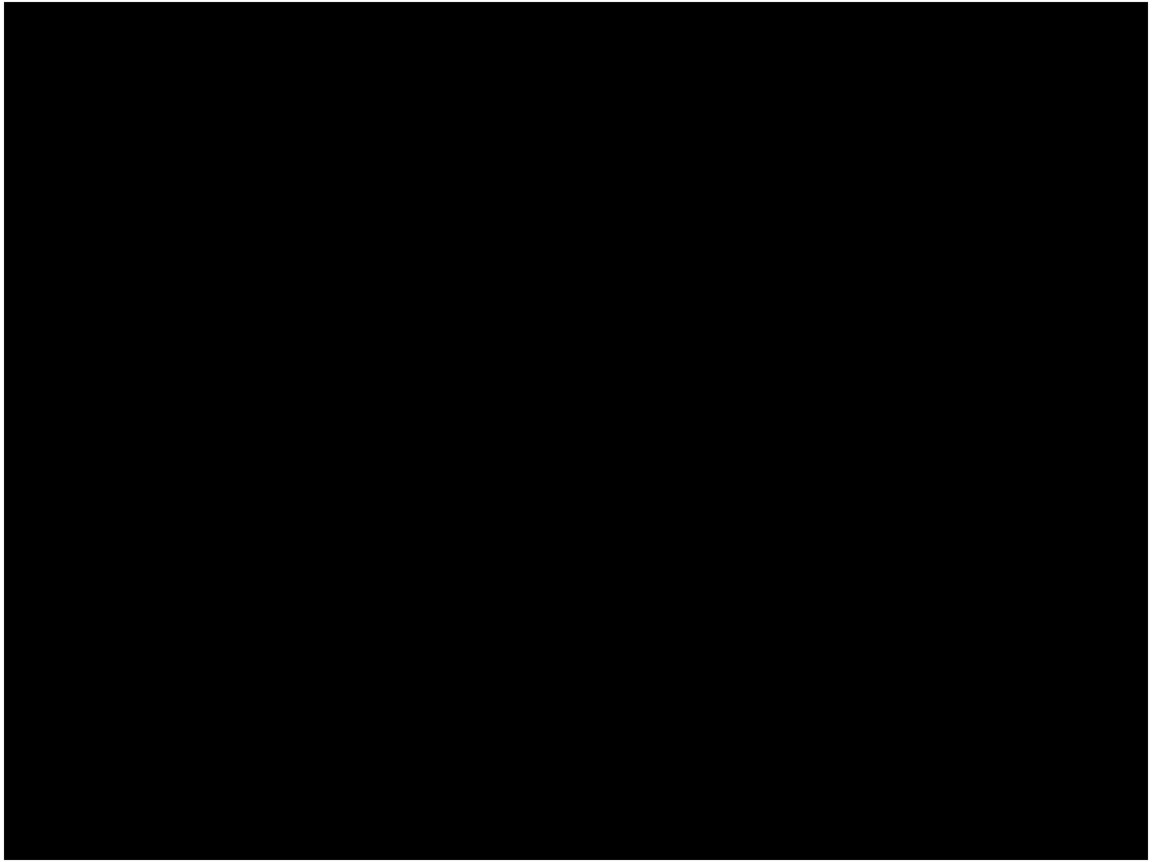
# Scanner In Action



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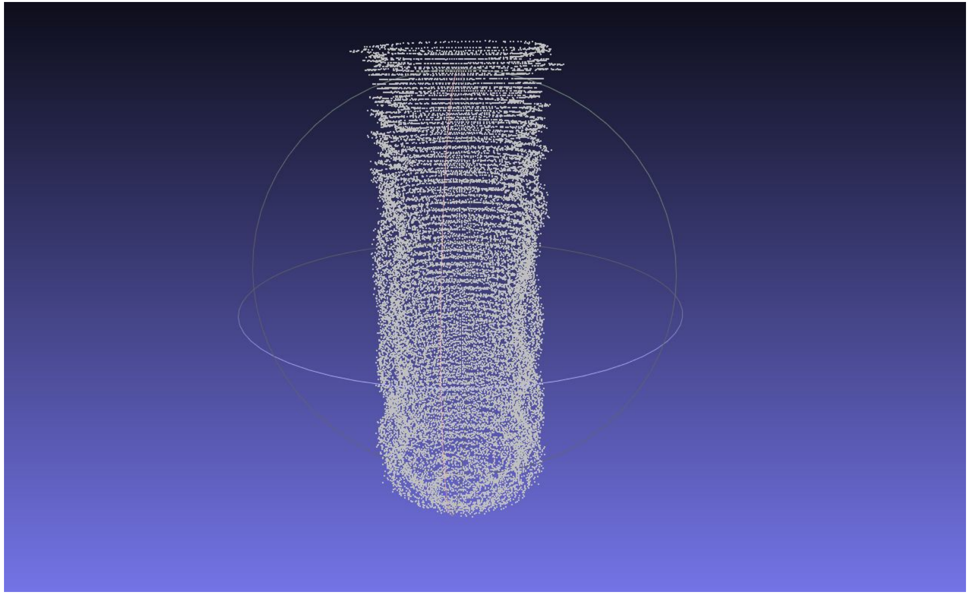
# Raw Output of Scanner



```
..........................................................................................
[info] Home position reached
....................................................
[info] Home position reached
[Debug] Calibration center: 193
...........................................................................................................................................................................
..........................................................................................
[info] Home position reached
....................................................
[info] Home position reached
[Debug] Calibration center: 192
...........................................................................................................................................................................
..........................................................................................
[info] Home position reached
....................................................
[info] Home position reached
[info] Scanning started
0 0 193
0 1 184
0 2 182
0 3 184
0 4 186
0 5 185
0 6 185
0 7 183
0 8 185
0 9 183
0 10 183
0 11 185
0 12 185
0 13 184
0 14 183
0 15 183
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0 19 185
0 20 184
0 21 185
0 22 183
0 23 184
0 24 185
0 25 185
0 26 182
0 27 181
```

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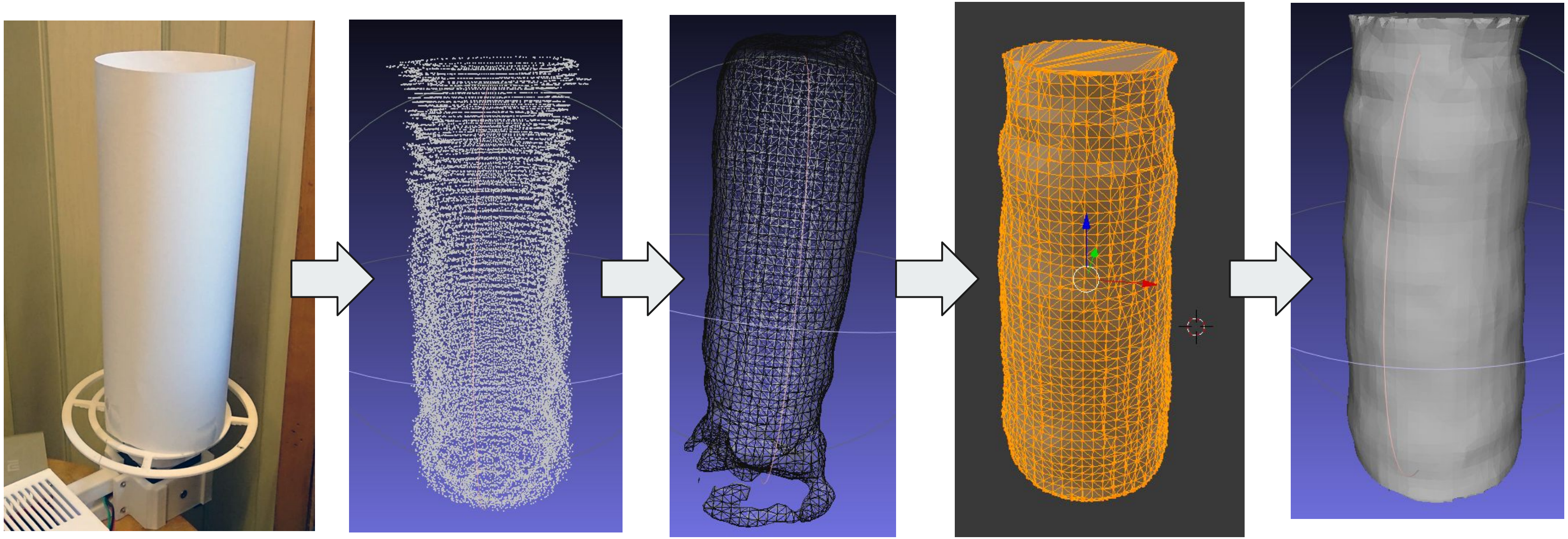
# Processed Scan Data



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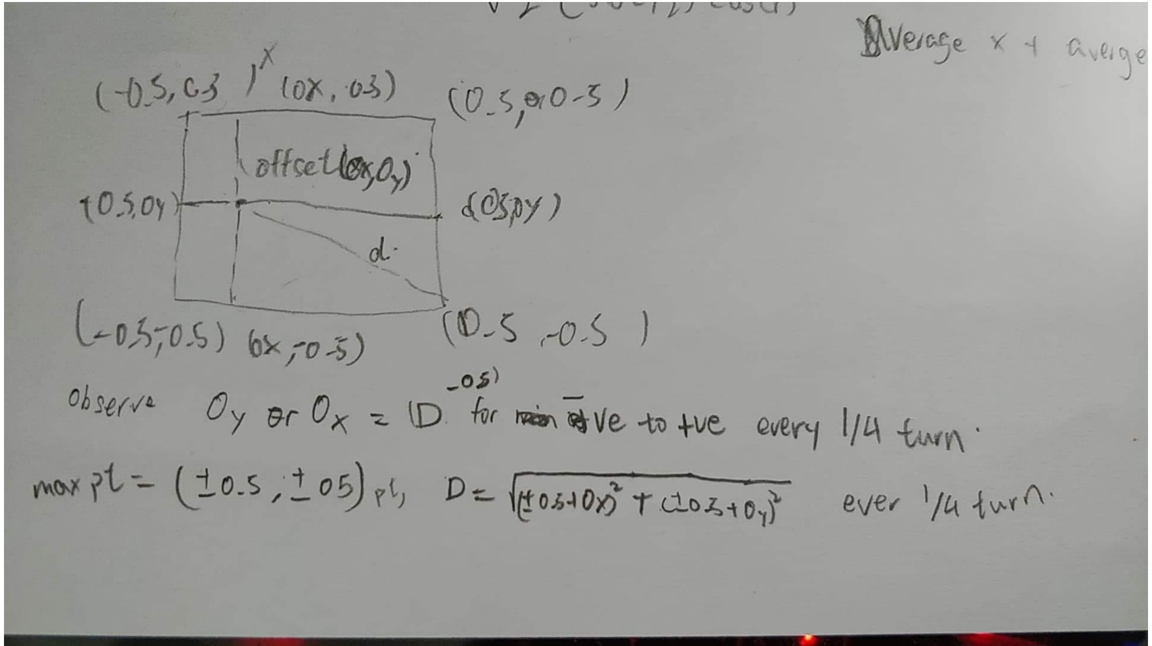
# Calibration formula deduction



# Assumptions

The placement of calibration box is off centered → unknow center point

The height ratio is straight forward: (top - bottom )/ steps

The depth is the complicated part.

x = depth * sin(theta), y = depth * cos (theta)

***But hey the box is off centered and we don't know any of x and y and theta!***

# Derive a function that link everything together

D =

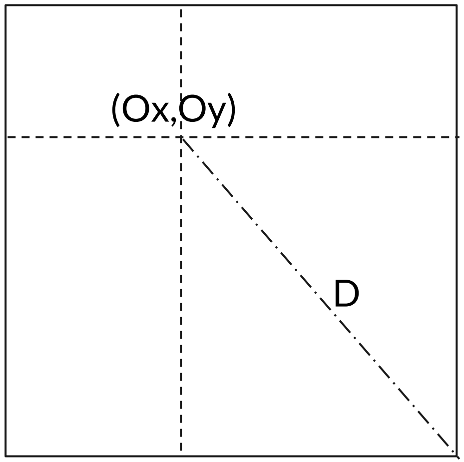
(side /2 + Ox) / sin(theta+offset) | 0<= theta <=pi/2

(side /2 - Oy) / sin(theta+offset) | pi/2<= theta <= pi

(side /2 - Ox) / sin(theta+offset) | pi <= theta <= 3pi/2

(side /2 + Oy) / sin(theta+offset) | 3pi/2<= theta <= 2pi

**Too complicate, we can go with only local minimum : (sin(theta)=1)**



# Going through the DARKNESS of calculus

We can eliminate variables using differentiation

$d D / dr = 0 \leftarrow$ solve r and left with 1 unknown

can be approximated by $D(r+\Delta r)-D(r)/\Delta r$

Also need to reject $d^2 D / dr > 0$ (local max)

# It gots clear at this point

at each local minimum

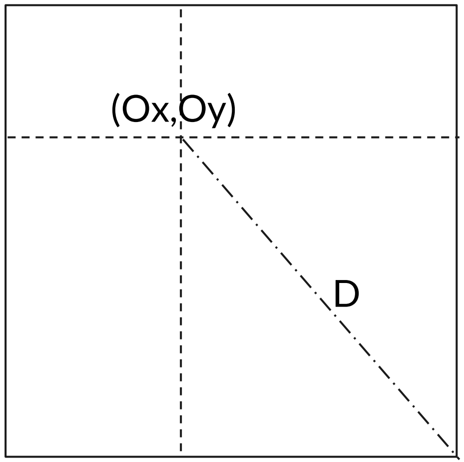
d_min ± (Ox or Oy) = depth (measured by sensor)

**One more trick**

**let Oy >= Ox**

**d - Oy <= d  - Ox <= d + Ox <= d + Oy**

**cancel out Oy, done**



# Cost Summary

| Item Name | Amount / Units | Cost (in HKD) | Remarks |
|---|---|---|---|
| 3D Printed Parts | Around 700g | $84 | Estimated Material Cost |
| VL53L1X | 1 | $336 | Replaced with Infrared sensor due to accident |
| GP2D12 | 1 | $78 | SHARP Infrared sensor |
| L298N | 2 | $35.3 x 2 | |
| Arduino UNO | 1 | $180.52 | |
| M3 * 5, M3 * 10, M3 * 20 screws | >20 | Neglectable | |
| | | Total (with ToF) | $671.12 |
| | | Total (with IR) | $413.12 |

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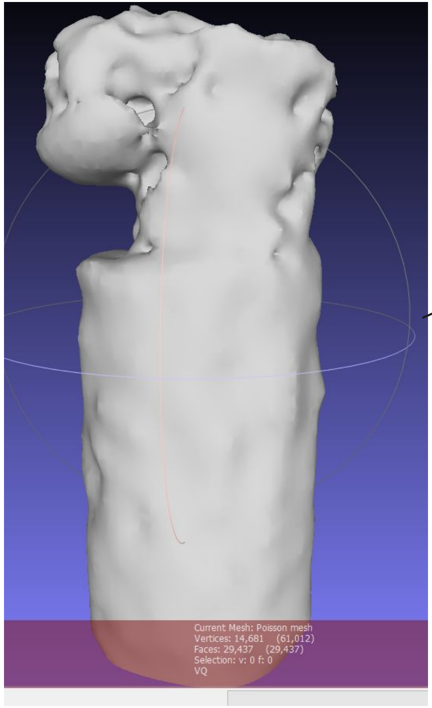
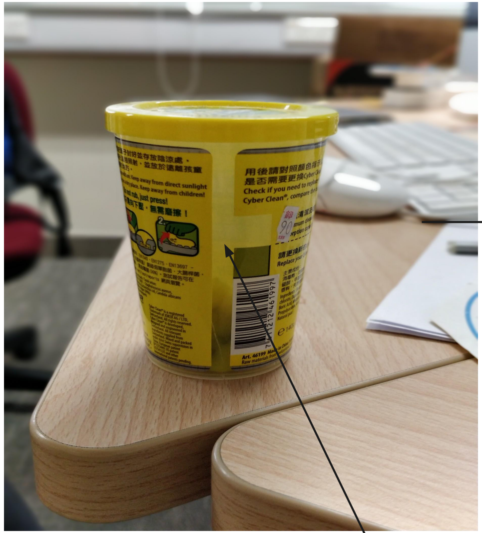
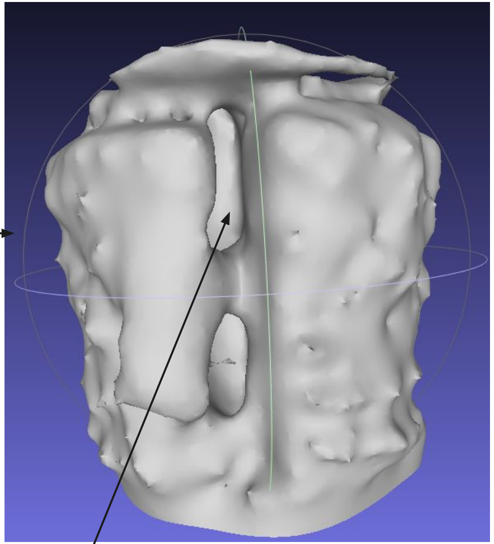
# Final Results


# Final Results





Transparent parts that cannot be scanned via IR sensor

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# Future Development

- Use dual sensor mode with Ultrasound Sensor to reduce error from reflection and transparent material
- Improve post-processing and scanning accuracy (This ToF Sensor is not the best one to suit this kind of application)
- 3D Copying Machine! (Scanner directly output gcode for 3D printer to print at the same time)
- Open Source

# THE END

Thanks for listening

# Reference and CopyRight



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