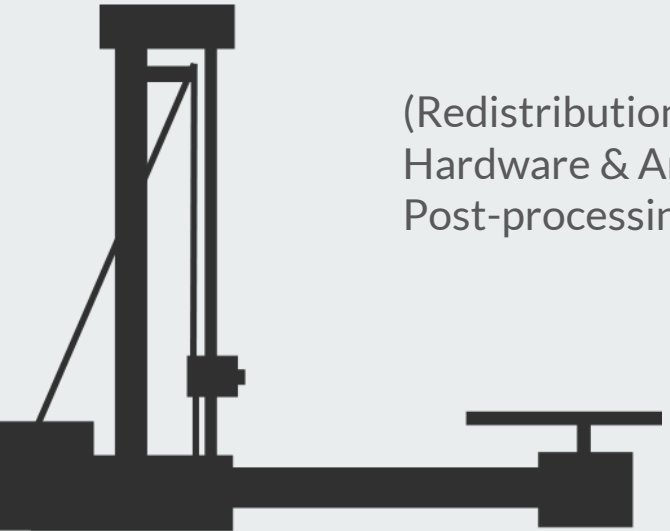
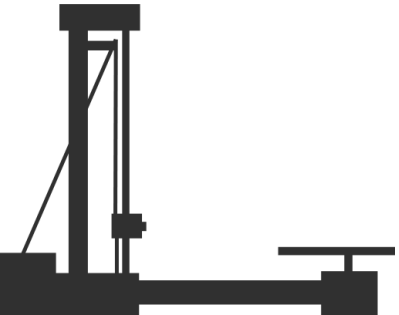
Budget 3D Scanner Project



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

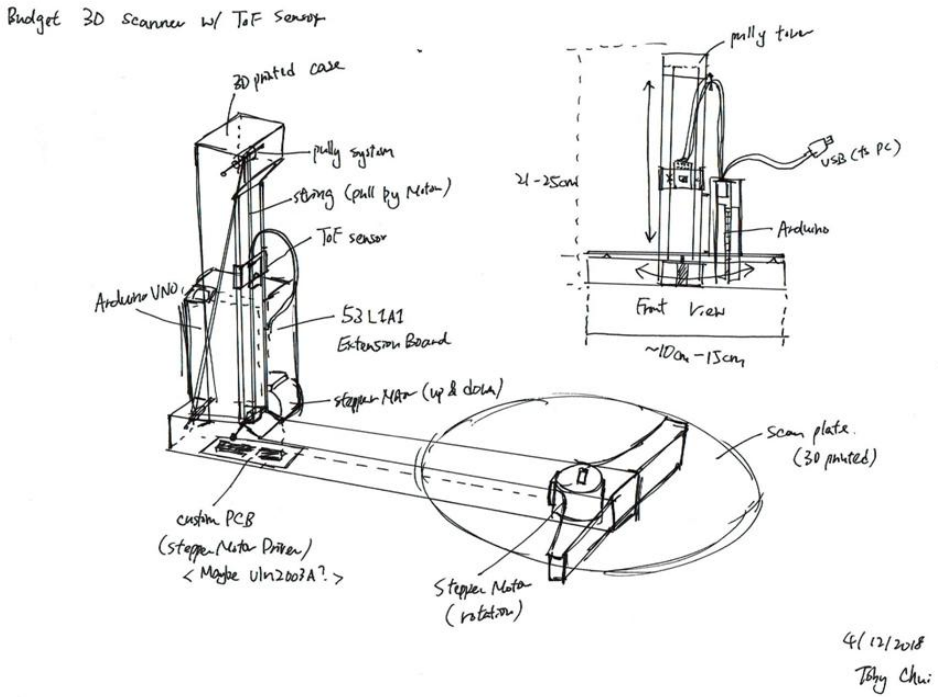
Introduction

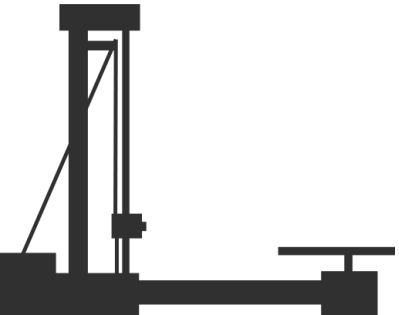
- 3D Scanners are kind of expensive right now but it has a wide range of application
- We want to make a low cost 3D scanner with ToF Sensor and two stepper motors as **Proof of Concept**
- Aim as create somewhat observable 3D models from one single sensor by converting the sensor data into point clouds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



Design Sketch

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





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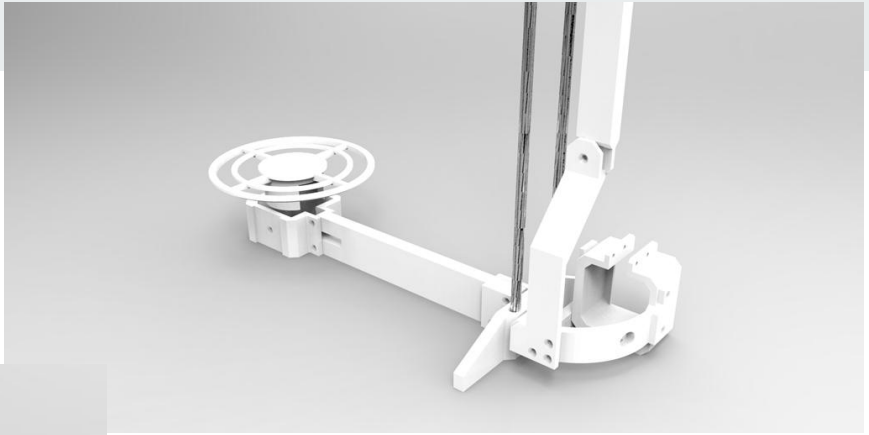
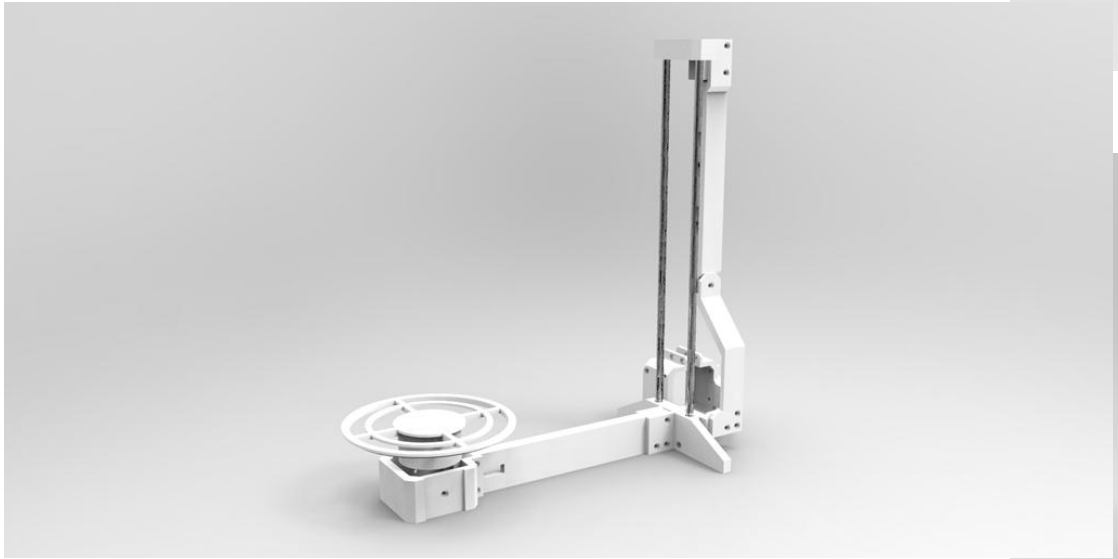
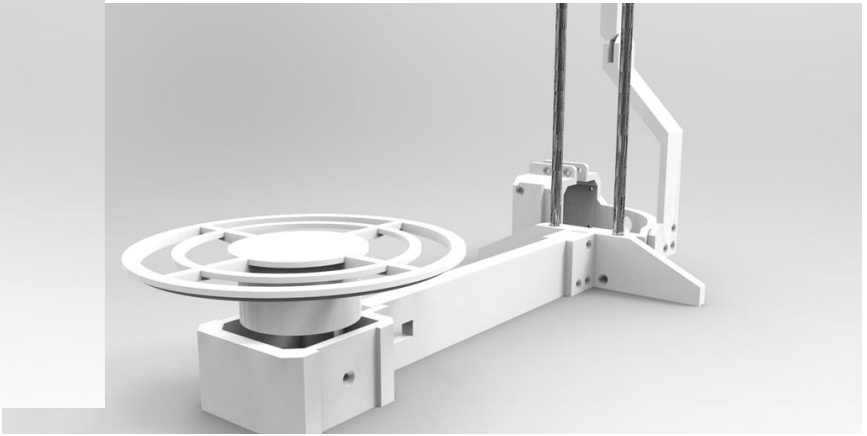
3D modeling (and render)



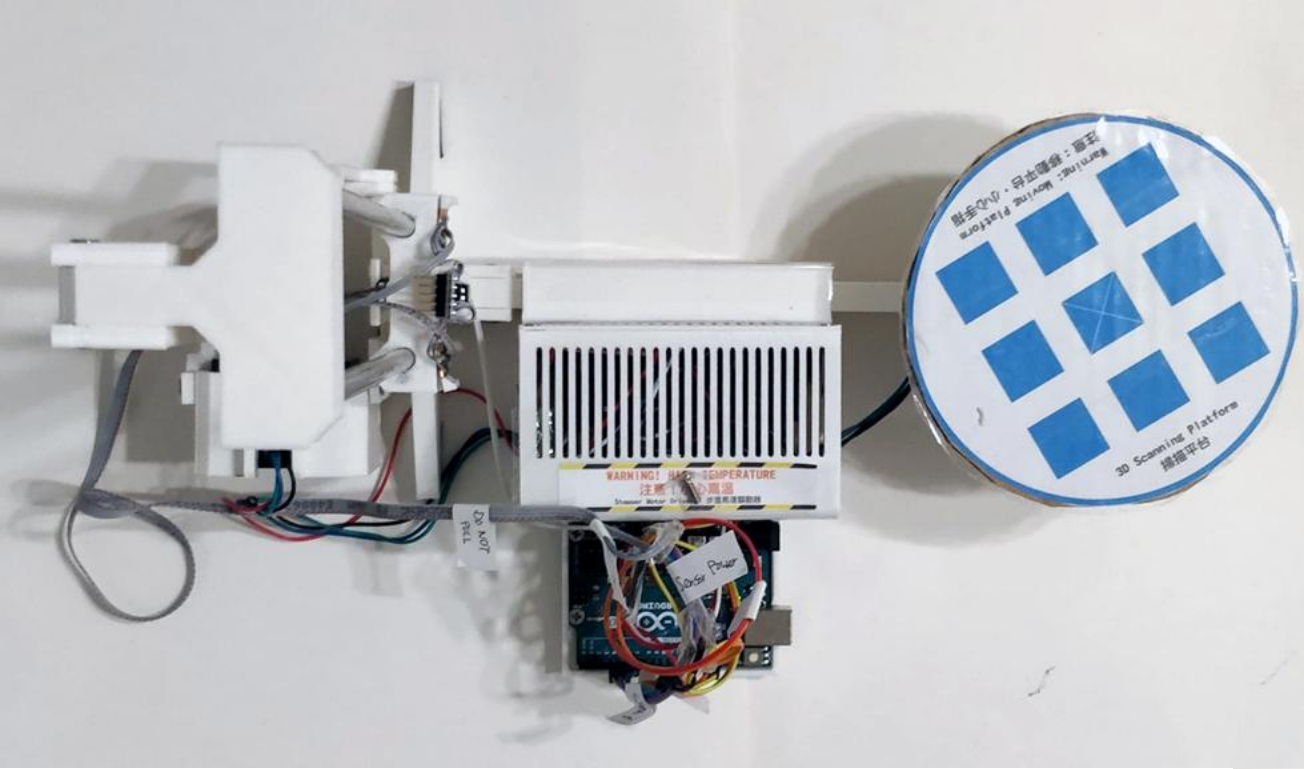


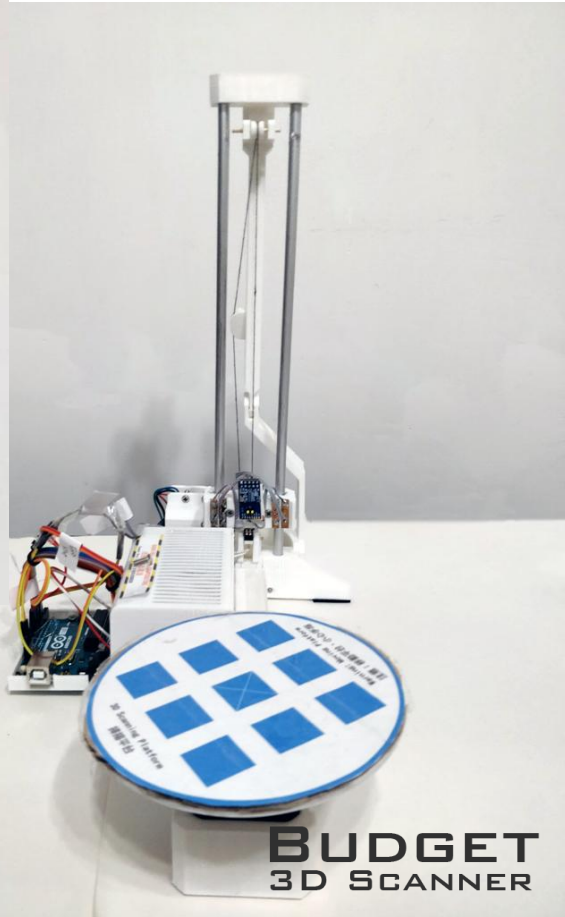


Final Product (Scanner)

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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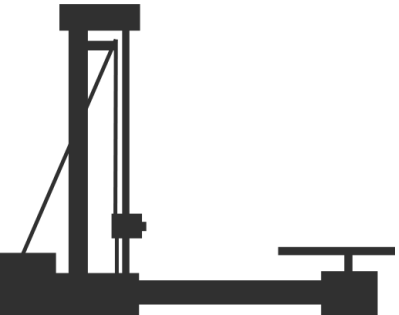
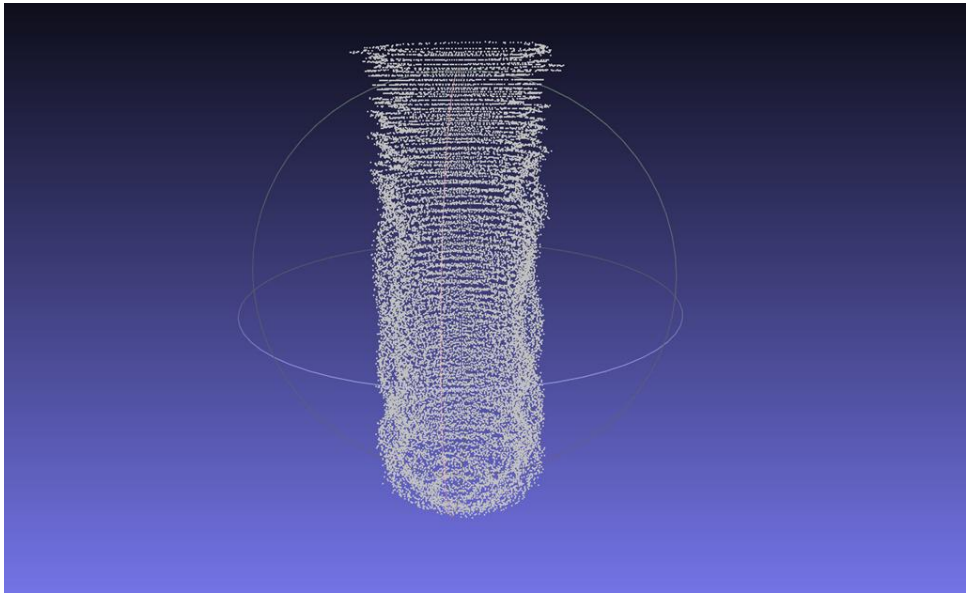
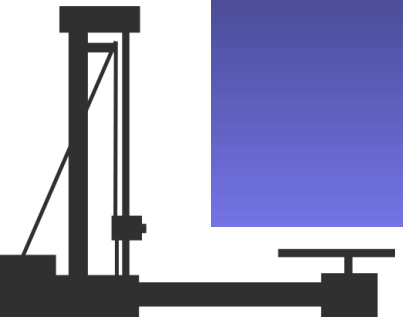
Scanner In Action



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
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0 12 185
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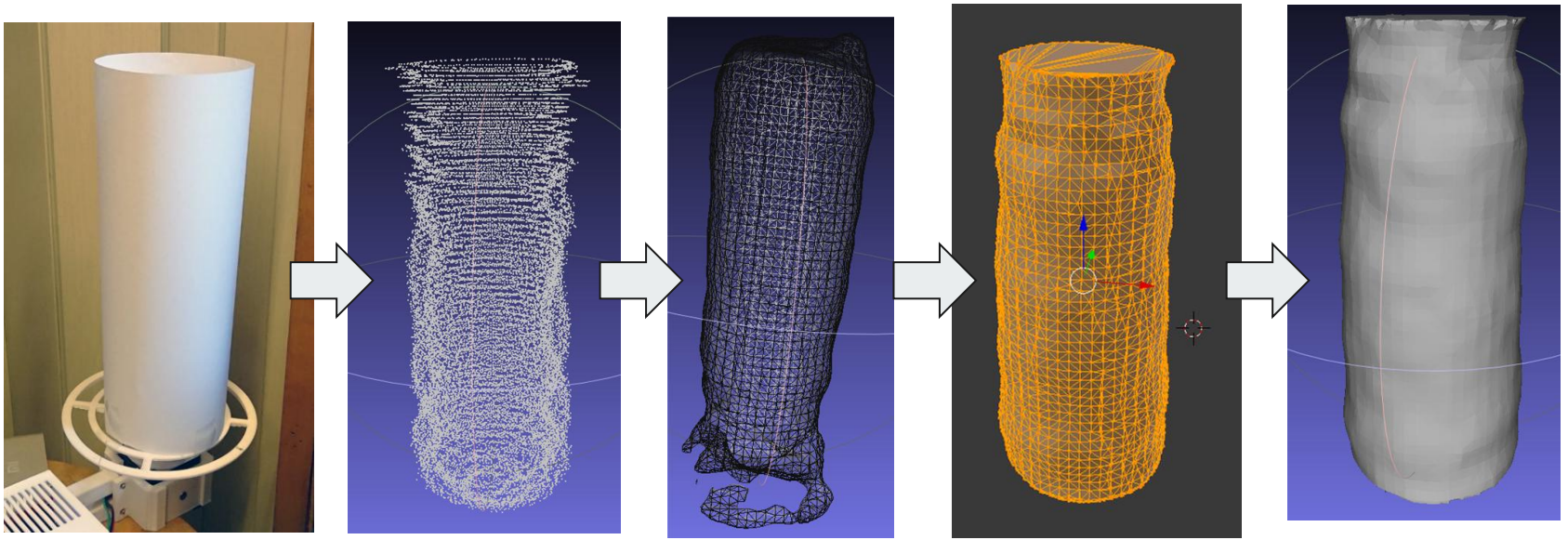
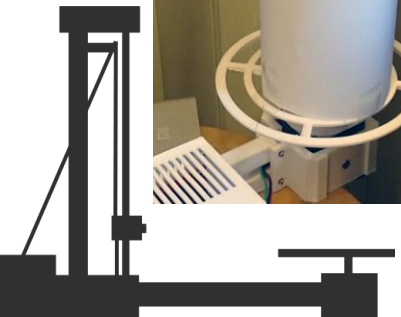
Processed Scan Data





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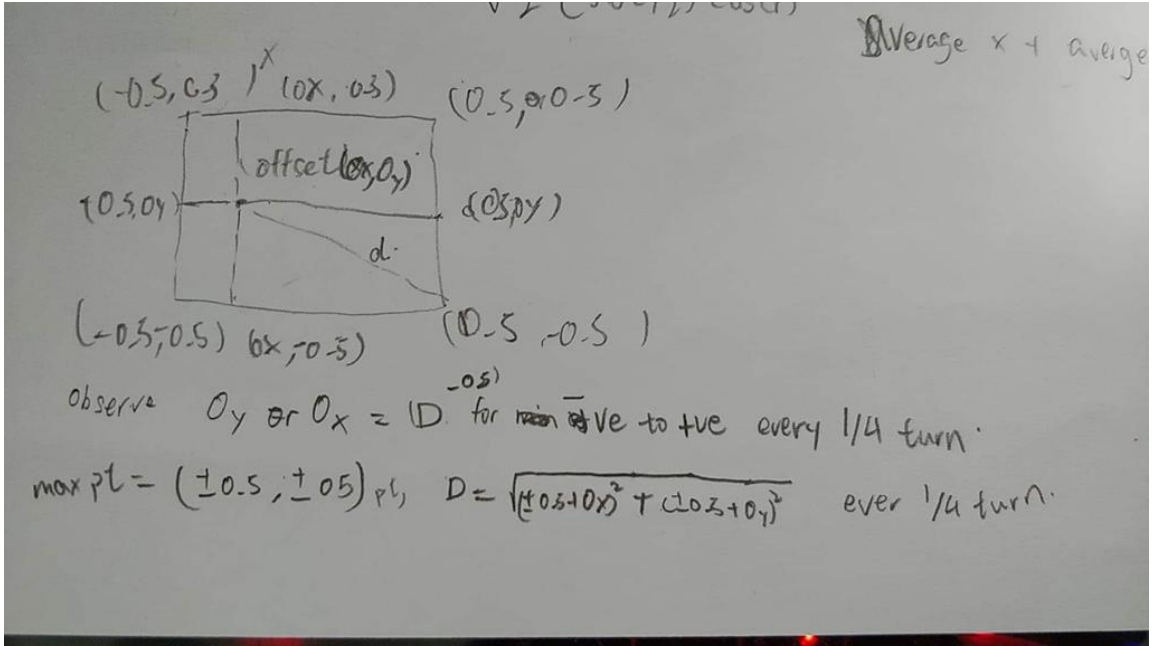
Calibration formula deduction



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 =

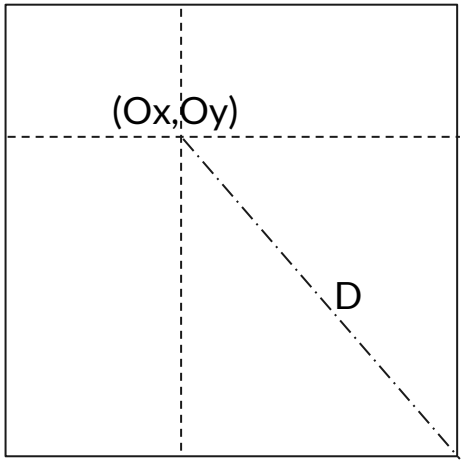
(side /2 + Ox) / sin(theta+offset) | 0<= theta <=pi/2

(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

$\frac{dD}{dr} = 0$ ← solve r and left with 1 unknown

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

Also need to reject $\frac{d^2 D}{dr} > 0$ (local max)

It gots clear at this point

at each local minimum

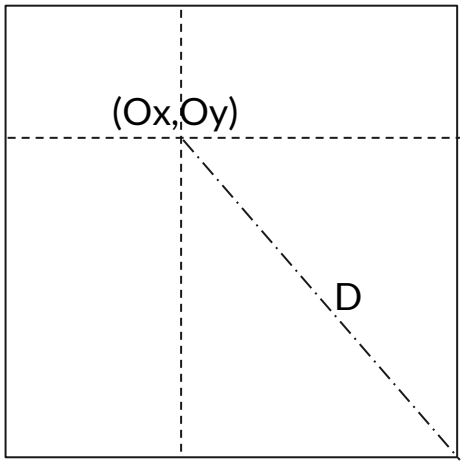
d_min ± (Ox or Oy) = depth (measured by sensor)

One more trick

let Oy >= Ox

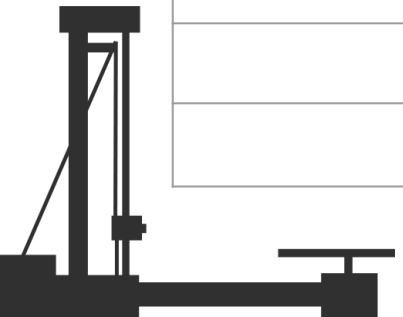
d - Oy <= d - Ox <= d + Ox <= d + Oy

cancel out Oy, done

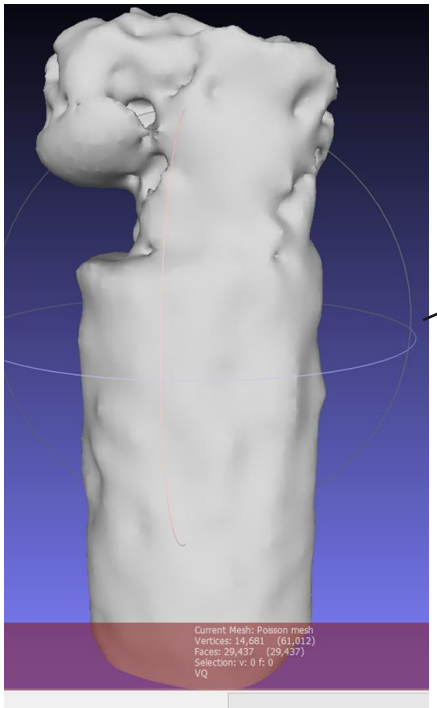


Cost Summary

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



Final Results



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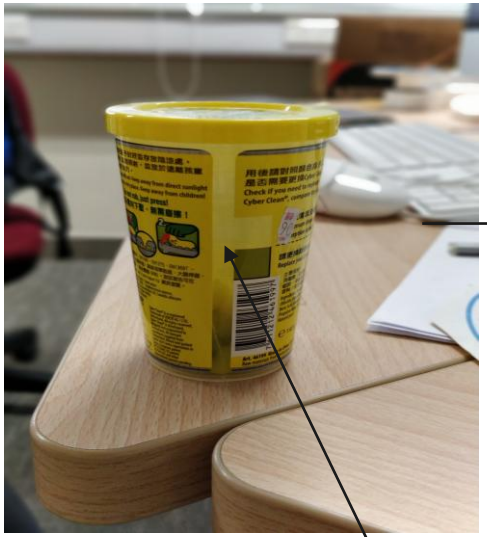
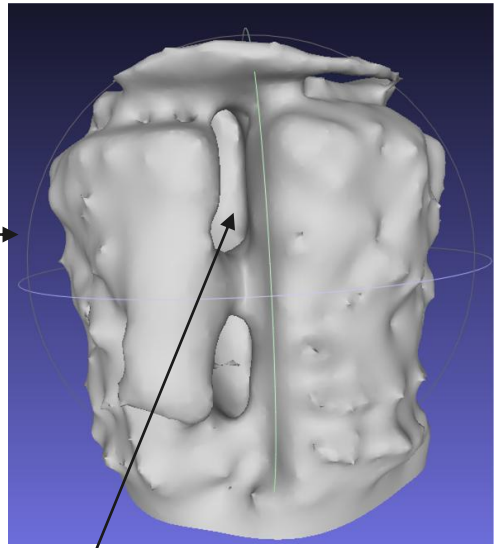
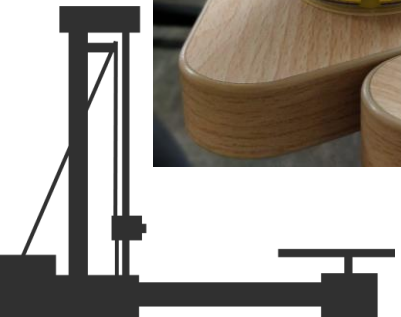
Final Results





Transparent parts that cannot be scanned via IR sensor



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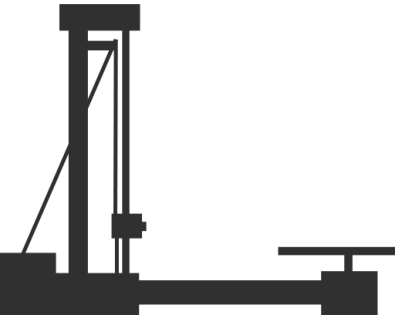
Future Development

- 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

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