Soil Testing

For improving the farming efficiency of Patchouli Oil in Indonesia using a Multiprobe Soil Sensor

Team 0105 A (Praxis III)
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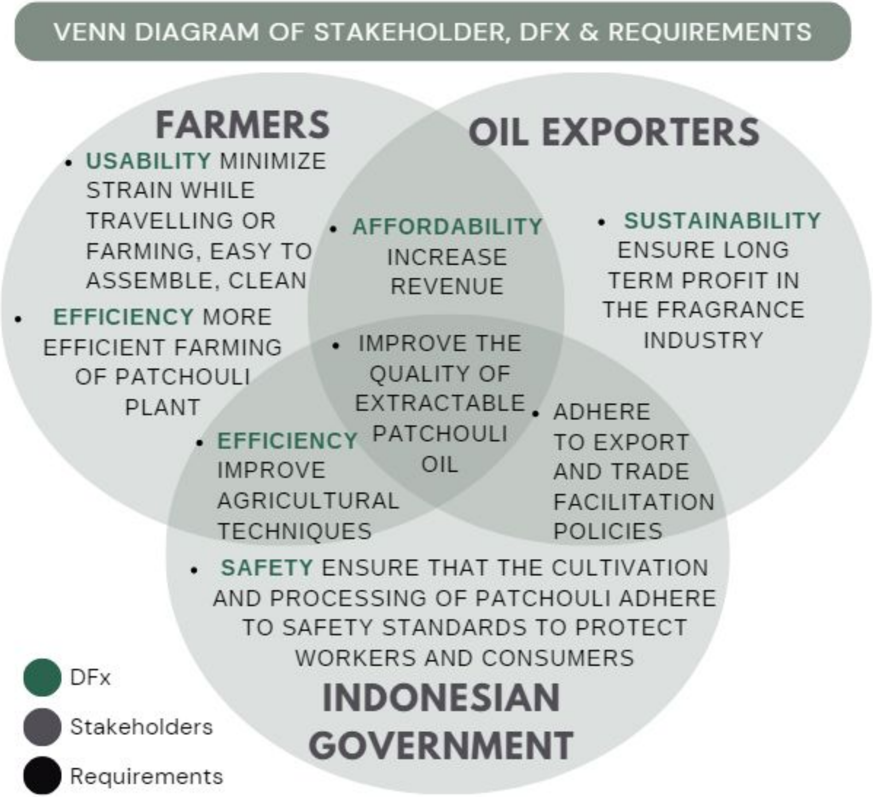
Opportunity Space

Sustainability

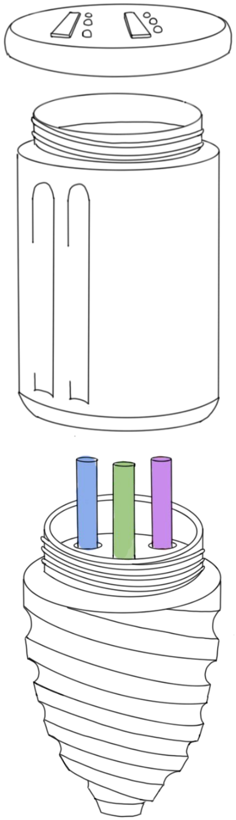
Improve patchouli oil quality

Grow farmer profits

Opportunity Space

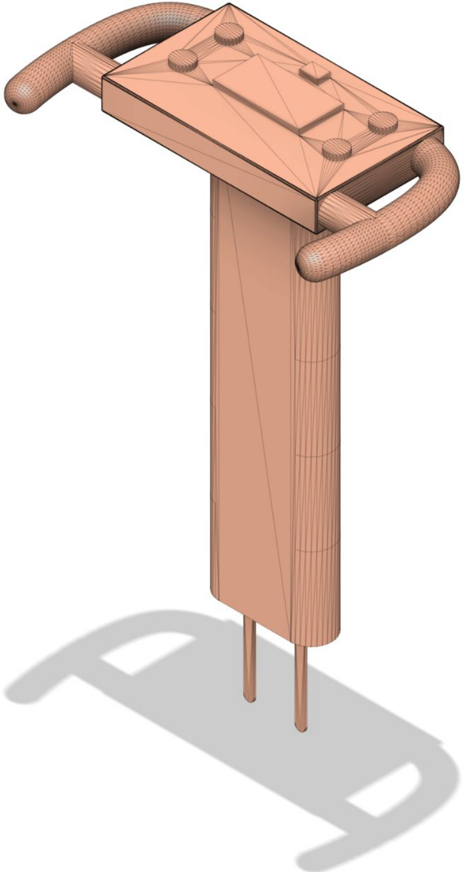


Modification to Design Approach



Original Design lacks:

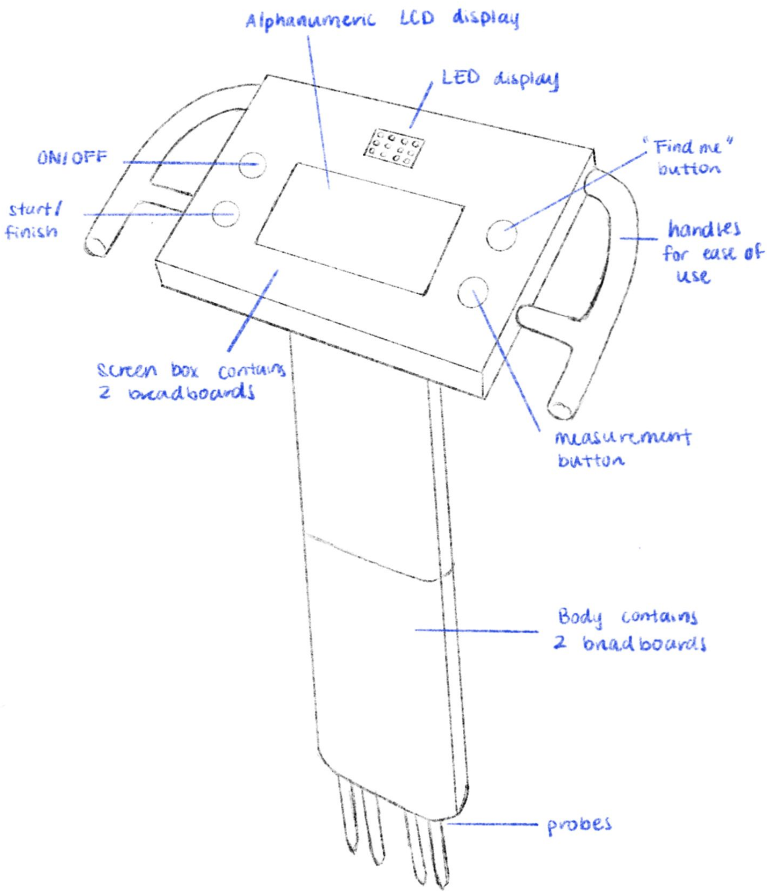
★ Durability
★ Difficult to Clean
★ Drill was unnecessarily complex

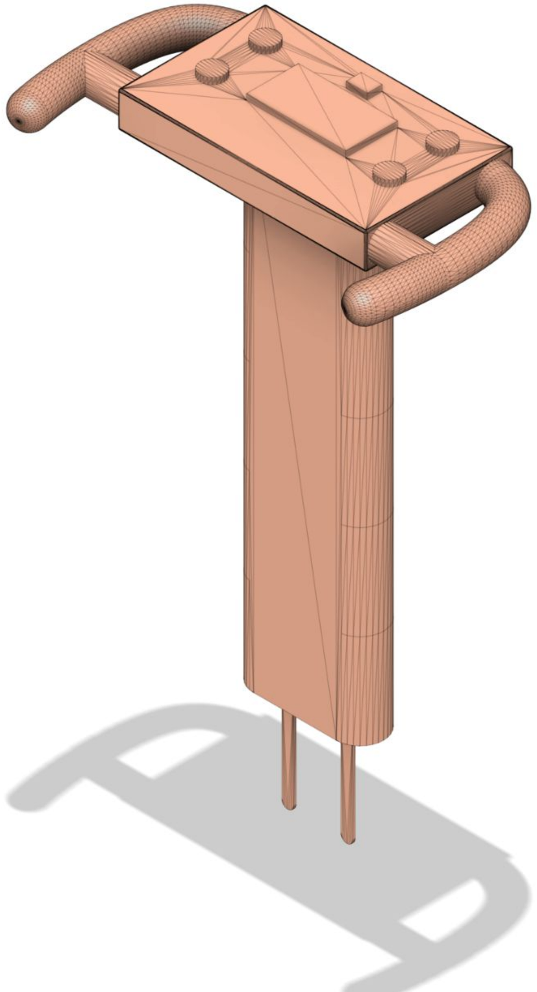


Core Functionalities

- Records moisture data and determines whether or not the soil is good for patchouli planting
- Displays the interpretation of the moisture data on the LCD screen.
- Uses farmer’s location to indicate which parts of the field have good or poor soil. This information is displayed on the LED matrix.

Overall System





DFX → Requirements

Primary Functional Requirement(s)

Objectives	Metric		Criteria	Constraint (if any)
	Characteristic	Unit		
1. The design is able to accurately detect nutrient content in the crop	# times nutrient is detected / # of trials	%	More is better	
Justification: Due to the need of the farmers and oil companies to boost production of patchouli oil in order to increase profit in the current rising market. Being able to consistently deliver accurate readings if crop health would help the efficiency of the planting process, hence increasing the production speed[4].				
2. The design displays interpretations of collected data, numerically and visually.	Accuracy of results on LCD and 5x7 LED matrix displays.	%	More is better	
Justification: Aids in conveying the sensor information to farmers in an easy-to-understand format. This is important when considering farmers may not have the technical skills to interpret probes directly, as well as keeping track of continuous information collection over long periods of time.				
3. The design is able to penetrate through soil	The torsion strength of the design	Pa (unit of	More is better	

DfX and other Requirements

Table 1 *Design for Cost-Efficiency*

Objectives	Metric		Criteria	Constraint (if any)
	Characteristic	Unit		
C1. The design is affordable	Final Product Price	$	Less	
Justification: In comparison to the national rates of poverty (9.82% in 2018), the rates of poverty for farmers in Indonesia are considerably higher at 15.97%[2]. Based on these statistics, it is important to consider the cost of the design such that farmers are able to afford using it while maintaining or growing their current revenue.				

Table 2 *Design for Safety*

Objectives	Metric		Criteria	Constraint (if any)
	Characteristic	Unit		
F1. The design should minimize worker exposure to hazards	Number of of incident reports	#	Less is better	
Justification: The adherence to safety standards ensures to protect workers and consumers. This includes adhering to Ministry of Agriculture regulations regarding the safe use of patchouli oil in products.				
F2. The design is free from hazardous materials	Percentage of hazardous materials used	%	Less is better	Must be 0%
Justification: Hazardous materials are hazardous to the farmers and the environment. Adheres to government regulation on hazardous and toxic substances management No. 74/2001.				
F3. The design is able to detect contaminants in the crop	Percentage of the times the design is able to accurately detect the existence of contaminants in the crop and soil	%	More is better	
Justification: Due to the rising trend of clean-labeled products, farmers and oil companies are attempting to improve or maintain their level of organicness of patchouli oil[4]. This includes preventing any unwanted contaminants in the crops. Currently, organic pesticides are being used to prepare the soil for patchouli growth.				

Table 3 *Design for Sustainability*

Objectives	Metric		Criteria	Constraint (if any)
	Characteristic	Unit		
S1. The design is made of local materials or scraps.	Number of components from local resources	#	More is better	
Justification: Local materials are easy to acquire for farmers living in isolated towns. There will be less cost and energy consumption associated with the transportation of materials. In the case that the design needs to be repaired, having the components of the design available to them is essential to have a product that will last long term[8].				
S2. The design is recyclable	Percentage of recyclable materials used	%	Less is better	
Justification: Having a design made with recyclable materials will lower the amount of waste that ends up unprocessed due to its unrecyclable nature[8]. This betters the sustainability nature of this product.				
S3. The design reduces carbon footprint	Percentage of CO2 emission	%	Less is better	
Justification: To optimize transportation and energy use in the manufacturing process to farm and produce the patchouli oil.				

Table 4 *Design for Usability*

Objectives	Metric		Criteria	Constraint (if any)
	Characteristic	Unit		
U1. The design is easy to operate.	Number of functional aspects, such as buttons	#	Less is better	
Justification: Since farmers will be preoccupied with several tasks, it is important to create an interface that requires less additional effort to use, primarily through a simple design with easily identifiable buttons, displays, etc.				
U2. The design allows for the growth of other crops	Number of distinct crops	#	More is better	

Justification:

1. To combat the problem of having to move soil patches after a few years, farmers use crop rotation in order to restore the nutrients in the soil. For patchouli farmers, they can grow cloves and citronella. The design must accommodate for crop rotation as it is an essential part of their agricultural practice[11].
2. The markets for patchouli oil fluctuate a lot, resulting in farmers focusing on other crops when the demand and

***Table 5** Design for Efficiency*

Objectives	Metric		Criteria	Constraint (if any)
	Characteristic	Unit		
E1. The design should increase the production yield	Oil weight produced per hectare of land	%	More is better	
Justification: Higher production yield will increase the farmer's income, which is an incentive for farmers' to grow patchouli[12].				
E2. The design should produce results in real-time.	Time taken to display sensor information.	[s]	Faster is better	
Justification: Although the information will be stored in a datasheet, it is important to have real-time results in order for the farmers to get a preliminary idea of the adequate farming space and better associate status of land to real world location.				

***Table 6** Design for Assembly*

Objectives	Metric		Criteria	Constraint (if any)
	Characteristic	Unit		
A1. The design is easy to use.	Number of components from local resources.	#	Less is better	
	Amount of time to set-up, use, and take-down,	[s]	Less is better	

Justification:

1. The amount of space travelled by farmers is considerably large, so the design should have minimal components to reduce the possibilities of losing important parts[8].

***Table 7** Design for Ergonomics*

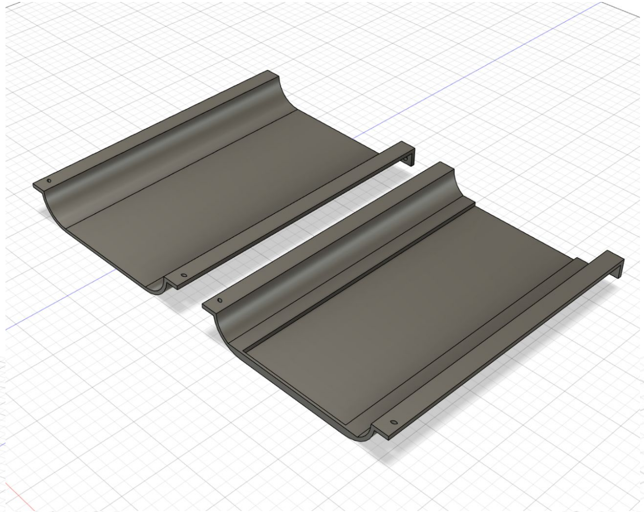
R1. The design is portable.	Dimensions of the product.	[cm]	Smaller is better	
	Weight of the product.	[g]	Less is better	

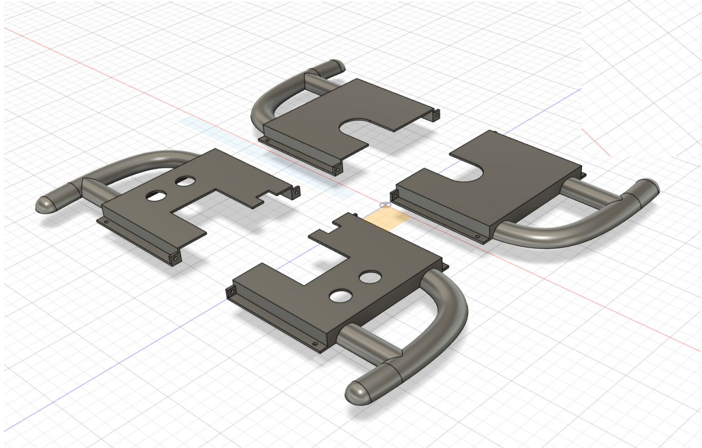
Justification: The patchouli fields are usually far from the farmers' villages, while distillation units are also a distance away. Planting sites themselves can cover around three hectares of land[8]. Thus the design should be easily portable for farmers to reduce strain and tiredness.

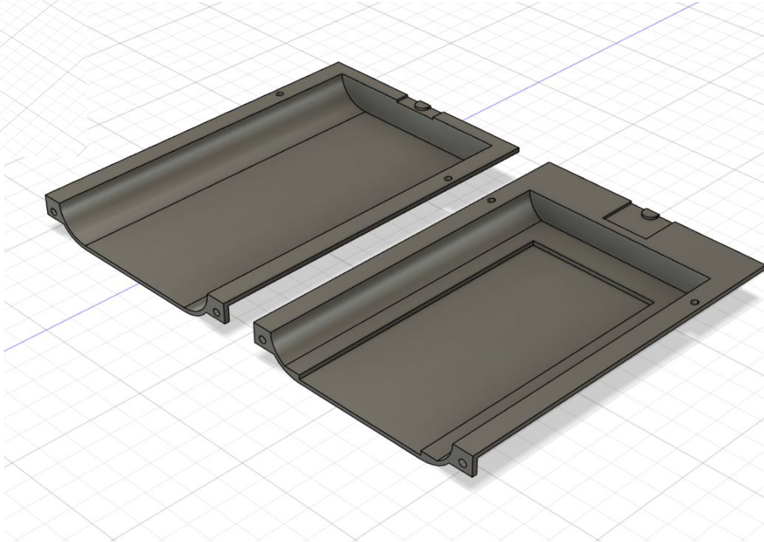
Prototypes

- Use GPS module to collect location
- Collect the moisture level from the moisture sensor and display the result on LCD
- Implement buttons that control the states

Structural Subsystem - CAD



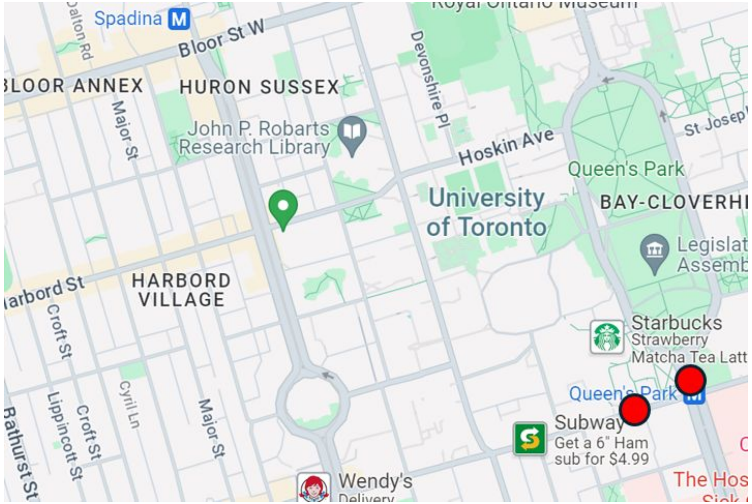


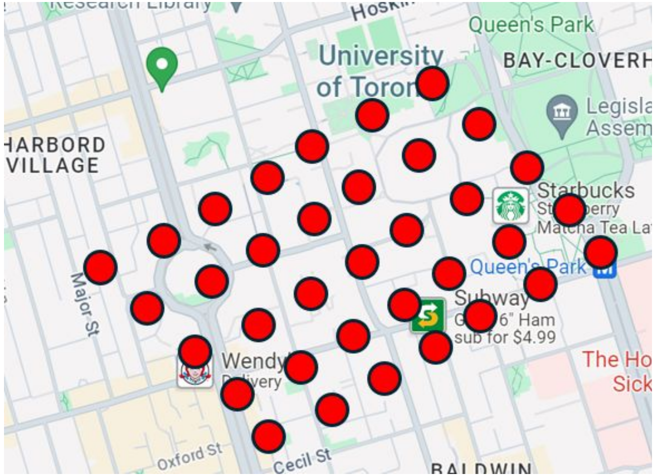


Structure is split in many parts due to the limitations of the 3D printer

Mapping

End goal of the algorithm is to extrapolate a matrix of all testing locations based on 2 initial locations





```python
def matrix_calc(coord1, coord2):
    bearing_hor = calculate_bearing(coord1, coord2)
    bearing_ver = bearing_hor + 90
    distance = vincenty_inverse(coord1, coord2).m
    matrix_final = np.zeros((5, 7), dtype = object)
    matrix_final[0][0] = coord1
    matrix_final[0][1] = coord2

    for i in range(0, 5):
        if matrix_final[i][0] == 0:
            matrix_final[i][0] = cal_new_coord(matrix_final[i-1][0], bearing_ver, distance)
        for j in range(1, 7):
            if matrix_final[i][j] == 0:
                matrix_final[i][j] = cal_new_coord(matrix_final[i][j-1], bearing_hor, distance)

    return matrix_final
```

Interfacing the Mapping Algorithm with GPS

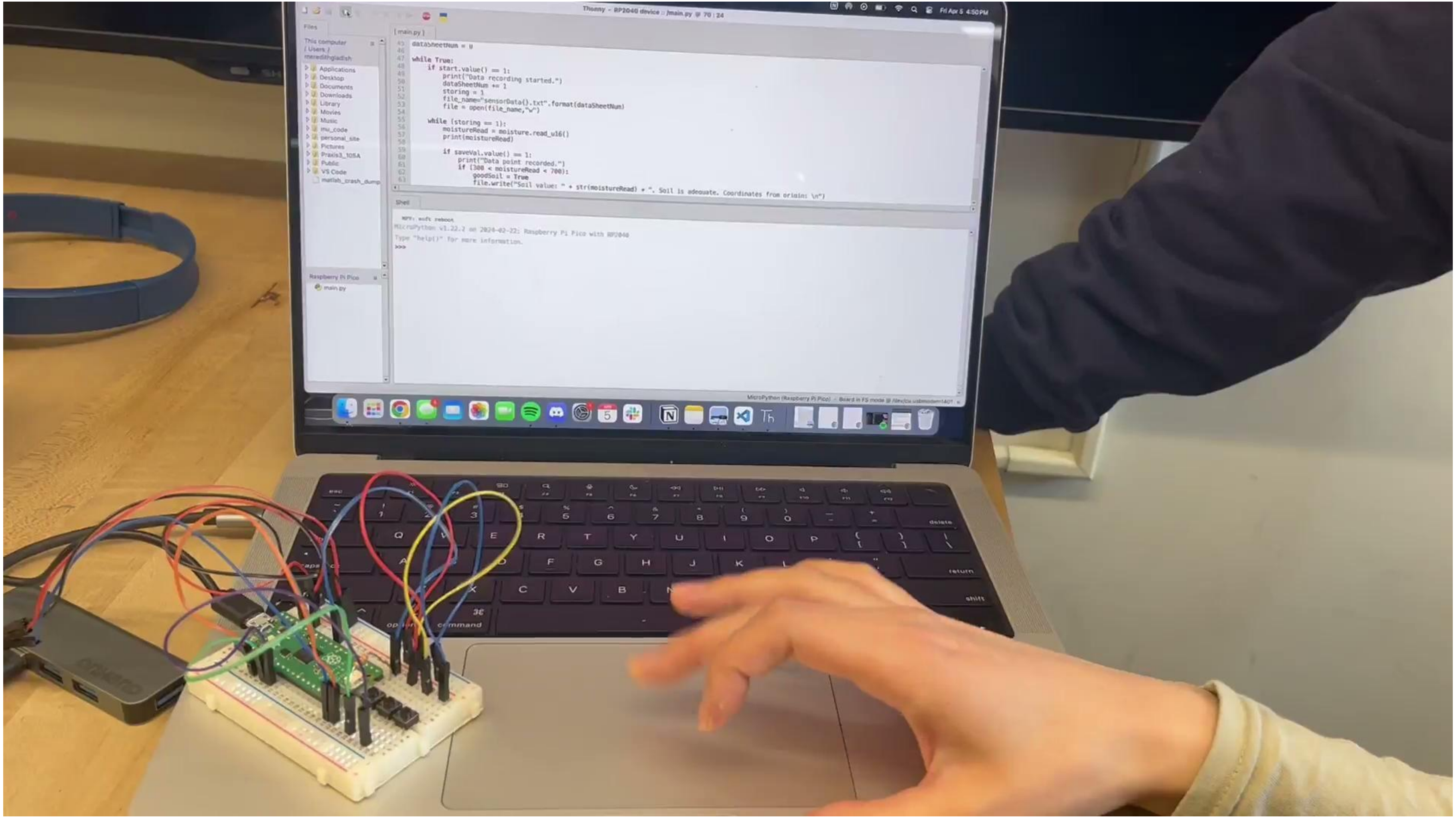
```python
parser = MicropyGPS(location_formatting='dd')

sentence = ''
def get_coord():
    while True:
        if gnss_l76b.uart_any():
            sentence = parser.update(chr(gnss_l76b.uart_receive_byte()[0]))
            if sentence:
                #print('WGS84 Coordinate:Latitude(%c),Longitude(%c) %.9f,%.9
                #if get_coord_button.value() == 1:
                lat = parser.latitude[0]
                lon = parser.longitude[0]
                return [lat, lon]
```

```python
    my_matrix = matrix_calc(coord1, coord2)
    return my_matrix
```

Button Testing & Datalogging

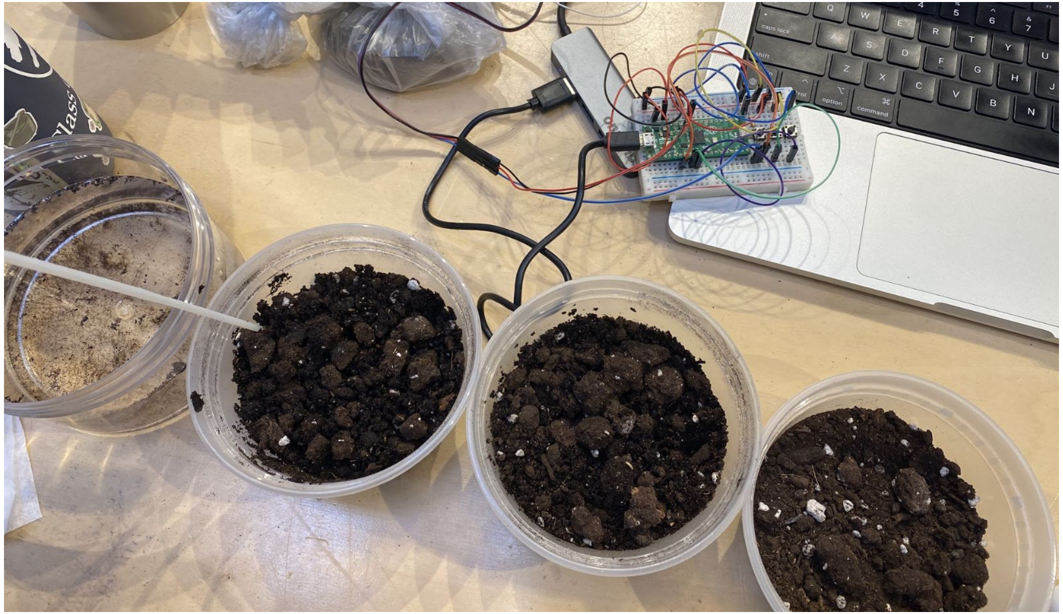
Button Functions	Expected Output on Terminal	Observed Output on Terminal
Start data collection	“Data recording started.”	“Data recording started.”
	Moisture value reading.	Moisture value reading.
Collect data point	“Data point recorded.”	“Data point recorded.”
End data collection	“Data recording ended.”	“Data recording ended.”
Locate farmer	GPS coordinates	GPS coordinates

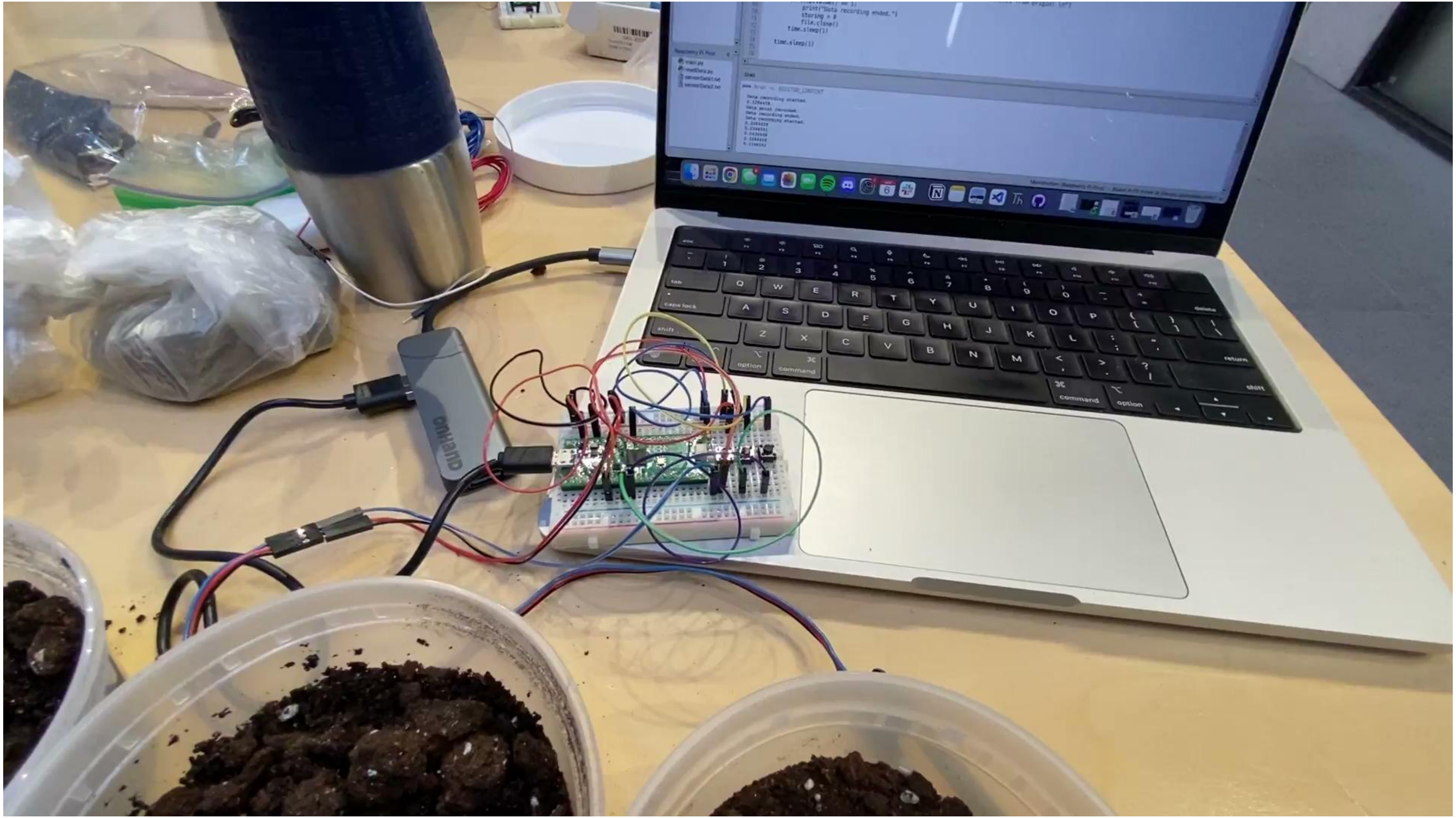
Datalogging Results	Expected Output	Observed Output
Collecting multiple sheets of data		
Start + start	The second start should not open a new datasheet.	Only one datasheet was produced.
Start + end + start + end	Two datasheets should be made with different names.	Two datasheets were produced, called sensorData1.txt and sensorData2.txt.
Start + collect*(n) + end	The datasheet would have n results stating, “[value]%, Soil is adequate/poor. Coordinates from origin: [coords].”	Tested without coordinates, but the rest of the lines were accurately produced. Each new data point was written on a new line.
Start + collect*(n) + end + start + collect*(m)	Only the first datasheet would be produced with results. The second data sheet would not contain information since it is not being closed.	The first datasheet showed results, however the second did not.
End	Nothing would occur	Nothing would occur
Collect*(n) + end	Nothing would occur	Nothing would occur


Thonny - RP2040 device :: /main.py @ 70 : 24
[main.py]
dataSheetNum = 0
while True:
if start.value() == 1:
print("Data recording started.")
dataSheetNum += 1
storing = 1
file_name="sensorData{}.txt".format(dataSheetNum)
file = open(file_name,"w")
while (storing == 1):
moistureRead = moisture.read_u16()
print(moistureRead)
if saveVal.value() == 1:
print("Data point recorded.")
if (300 < moistureRead < 700):
goodSoil = True
file.write("Soil value: " + str(moistureRead) + ". Soil is adequate. Coordinates from origin: \n")
Shell
MicroPython v1.22.2 on 2024-02-22; Raspberry Pi Pico with RP2040
Type "help()" for more information.
>>>
Applications
Desktop
Documents
Downloads
Library
Movies
Music
Pictures
Public
VS Code
Raspberry Pi Pico
main.py

Soil Testing

Soil type	Expected Output	Observed Output
In air	~0 percentage value	~0.2-0.3%, “poor”
Dry soil (no added water)	Low percentage value	~6%, “poor”
~50% water added	Lower range but adequate	~46-48%, “adequate”
~60% water added	Higher range but adequate	~61-62%, “adequate”
Water	High percentage value	~64-65%, “poor”




print("Data recording ended.")
file.close()
time.sleep(1)
time.sleep(1)
Data recording started.
Data recording ended.
Data recording started.


5

Project Management - Progress Tracker

Subsystem	Item	Interim Deadline	Anusha	Harry	Marcus	Jason	Kate	Meredith	Completed	Finished on...	Extra Notes
	LCD Display Circuit	4th April	🥳	🍆					✅		
	LED Matrix Circuit	4th April		🍆	🦬			👺	😟		Only able to light up one LED on the LED Matrix
Electrical	GPS Circuit	8th April			🦬	🍑			✅		
	Soil Moisture Sensor Circuit	1st April						👺	✅	5th April	
Mechanical	Handle and display housing unit (CAD)	27th March				🍑	🎃		✅	24th March	Printed on 27th March
	Main circuit housing unit (CAD)	27th March				🍑	🎃		✅	24th March	Printed on 27th March
	GPS and location matrix code	6th April			🦬	🍑			✅		
	Soil Moisture Sensor code	6th April						👺	✅	6th April	
Software	LED Matrix code	6th April		🍆	🦬			👺	😟		Only able to configure 1 LED to turn on
	LCD Display code	6th April	🥳	🍆					✅		
	Datalogging	6th April						👺	✅	6th April	

Next steps

★ Add NPK and pH sensors
★ Continue 5x7 LED mapping implementation and testing
★ Retest soil testing
★ Adjust structural component to consider other probes
★ Adjust breadboard configuration
★ Add battery