Microwave-based Soil Carbon Sensing

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Abstract

- Investigate the potential of an effective and affordable microwave based proximity sensor to classify and evaluate carbon levels in varying soil samples.
- In cooperation with colleagues to develop and produce a set of testing procedures to provide valid raw data results.
- Aid in the research advancements towards soil carbon related topics with innovative and improved methods of soil carbon sensing.
- Develop personal skills and experiences in the SSI program to refine my capabilities as an undergraduate research in preparation for graduate school.

Introduction: Why? Why us?

- **Why**: Soil carbon sensing has become a hot topic in today's world as people push for more sustainable methods in the realm of agriculture. The means to classify and evaluate carbon levels in soil are limited, require too much time/energy, or unaffordable for more state of the art sensing equipment. Finding new, affordable, and effective options to conduct carbon sensing in the soil would greatly benefit in a multitude of ways. By understanding the amount of carbon in the soil farmers are able to improve their productions, rural regions can better manage soil health, and effectively conduct environmental sustainability efforts.
- **Why us**: Our solution for an affordable and effective soil carbon sensor involves the use a microwave based radar system. Tests are currently being conducted to evaluate the validity of this sensor and measuring the capabilities that our product has over alternative options. The work occurring has the potential to greatly improve agriculture work as a whole while making it accessible to local farmers.

Figure 1. Vayyar Element 4D Sensor model used for Independent Testing.

Our Contributions

Below are the main points of focus we are testing to develop an efficient and accurate sensor using the antenna configurability of the Walabot sensor for object detection and classification:

1. Material Identification: Collecting raw data signatures from soil, biochar, and soil/biochar mixture samples to evaluate the capabilities of different antenna configurations on different samples.

2. Effective Scanning Range: By testing the Walabot at different distances, we can investigate how the antenna configurations affect the range capacity of our sensor.

3. Backend Interactions: When scanning, objects behind the samples can affect the results of the raw dat. This narrows down the variables affecting the function of our sensor.

We are working with a 40x20 antenna arrays which gives 800 different combinations to test, a python script was written to test all variations in the span of an hour.

Results

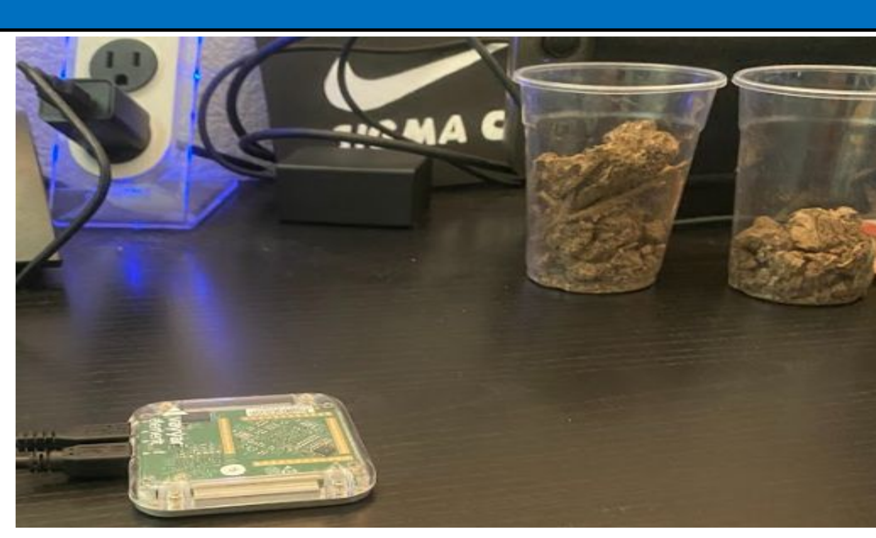

Figure 2. Independent Experiment layout for one of the sensors of interest.

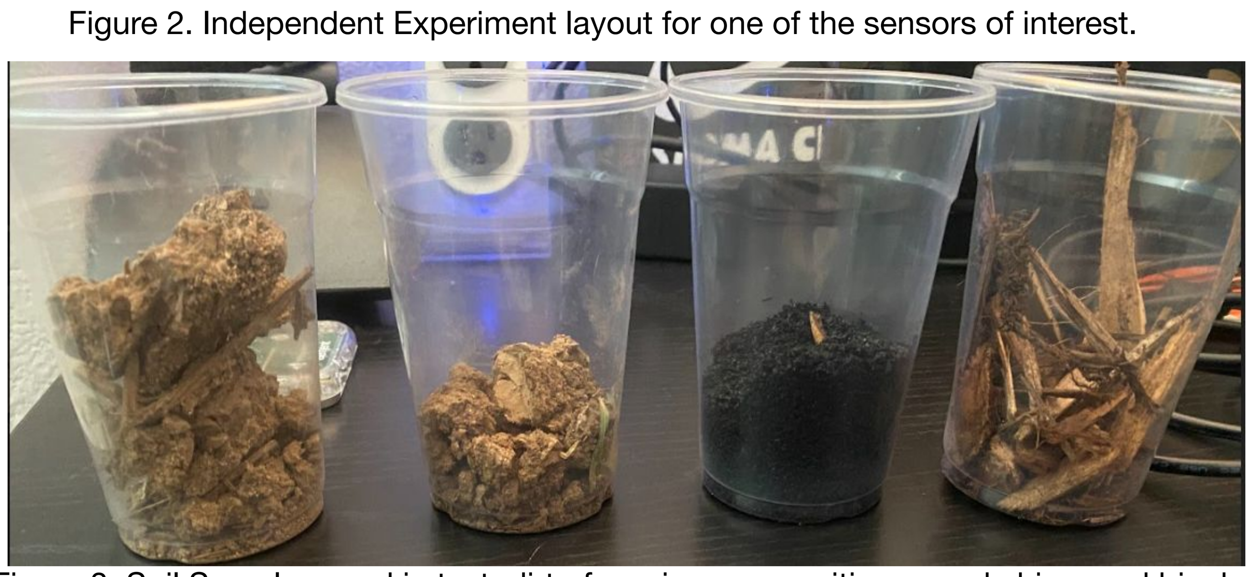

Figure 3. Soil Samples used in test; dirt of varying composition, wood chips, and biochar.

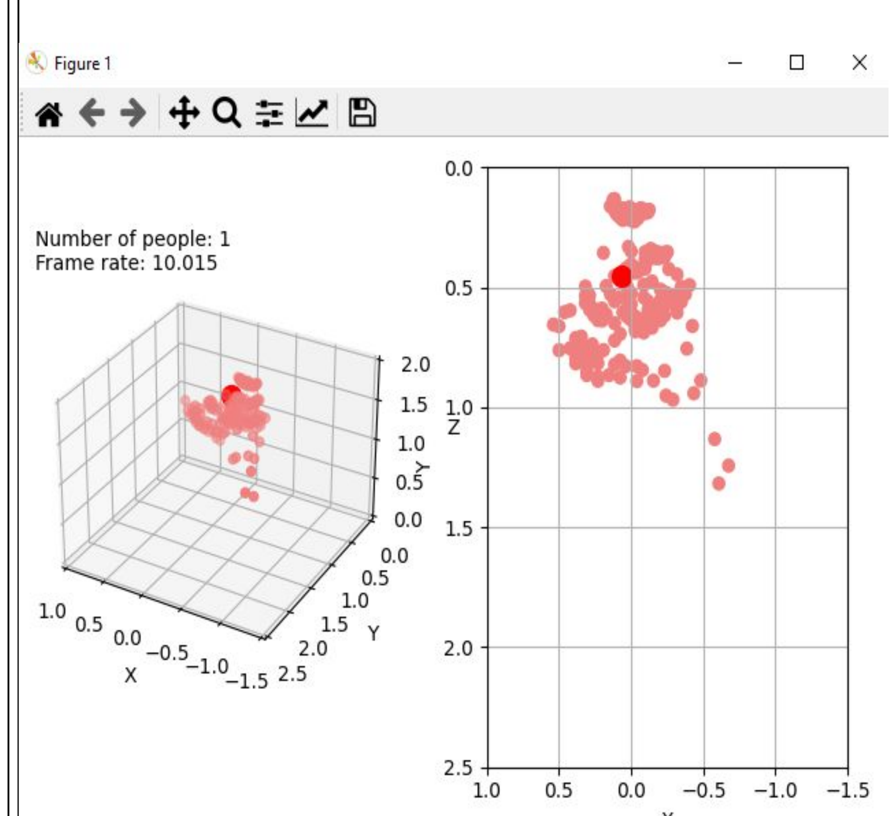

Figure 4. Data collected from results of test of dirt sample (in meters).

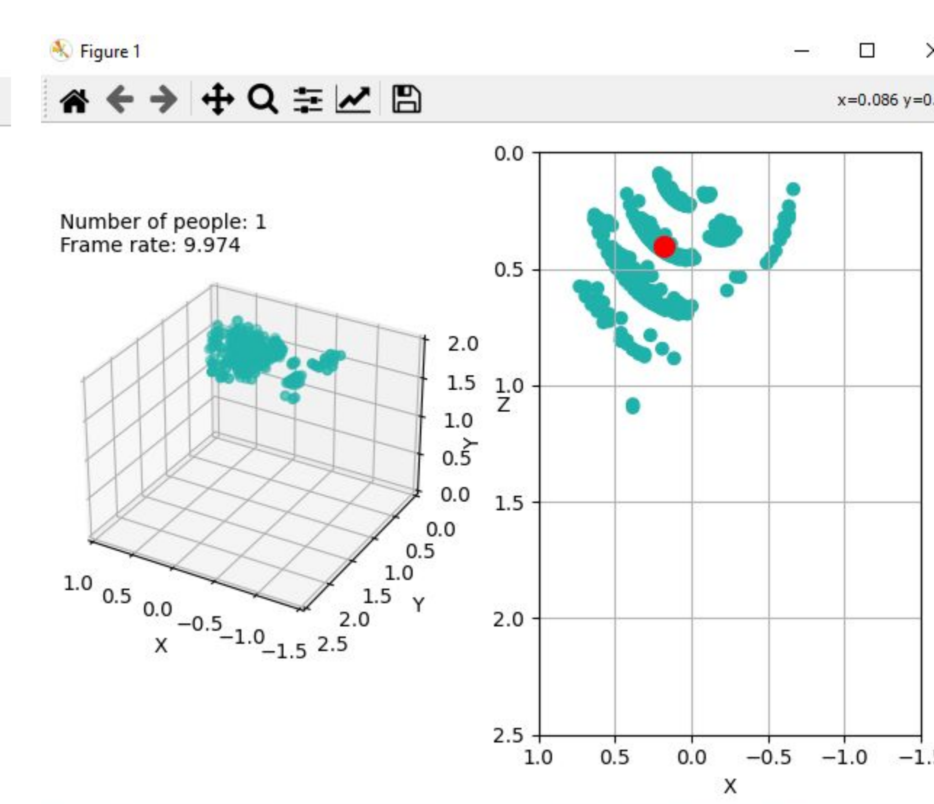

Figure 5. Data collected from results of test of biochar sample (in meters).

Discussion / Conclusion

- Through extensive literature review on mm-waves and microwaves, a great deal of insight into the best applications of our sensors was obtained.
- Investigations were made into existing soil carbon sensing alternatives and examine their capabilities to better understand what already works to develop more improved methods.
- Conducting experiments with multiple sensors to evaluate how each radar system functions when subjected to varying environments, materials, and distances.
- Developing current testing procedures with colleague to test our primary choice of proximity sensor for carbon soil sensing.
- Once these new testing procedures are implemented, we believe that our microwave-based sensor has potential to be a beneficial alternative method of detecting and classifying carbon compositions in soil samples.

- **Future Work**: Current tests are being conducted on our sensor of interest with experiment procedures we developed to validate our current data sets and begin work on producing a research paper based on our findings before attending graduate school at UC Merced in Fall of 2022.

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