Ubiquitous soil sampling robots for confluent soil monitoring

SoilBot for soil health monitoring and phenotyping maize root *in situ*

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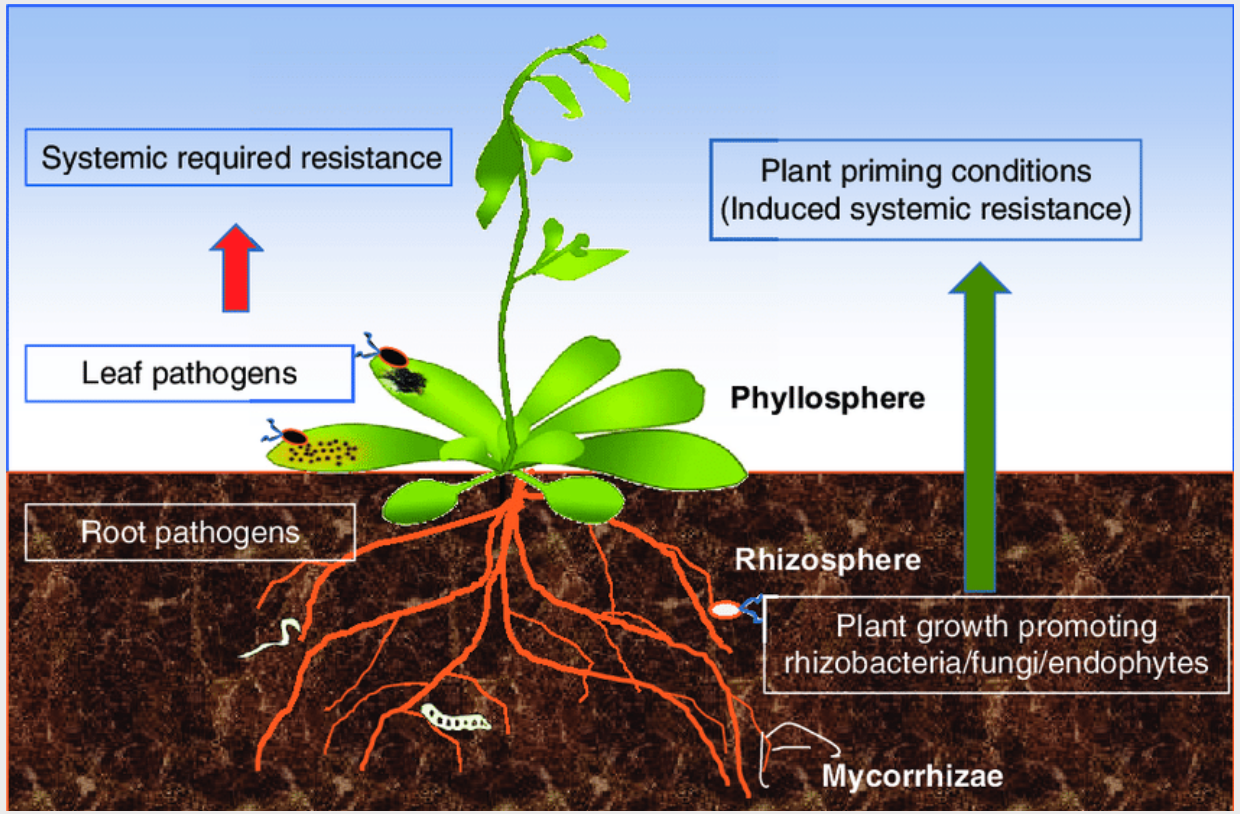
CornellCALS

Rhizosphere

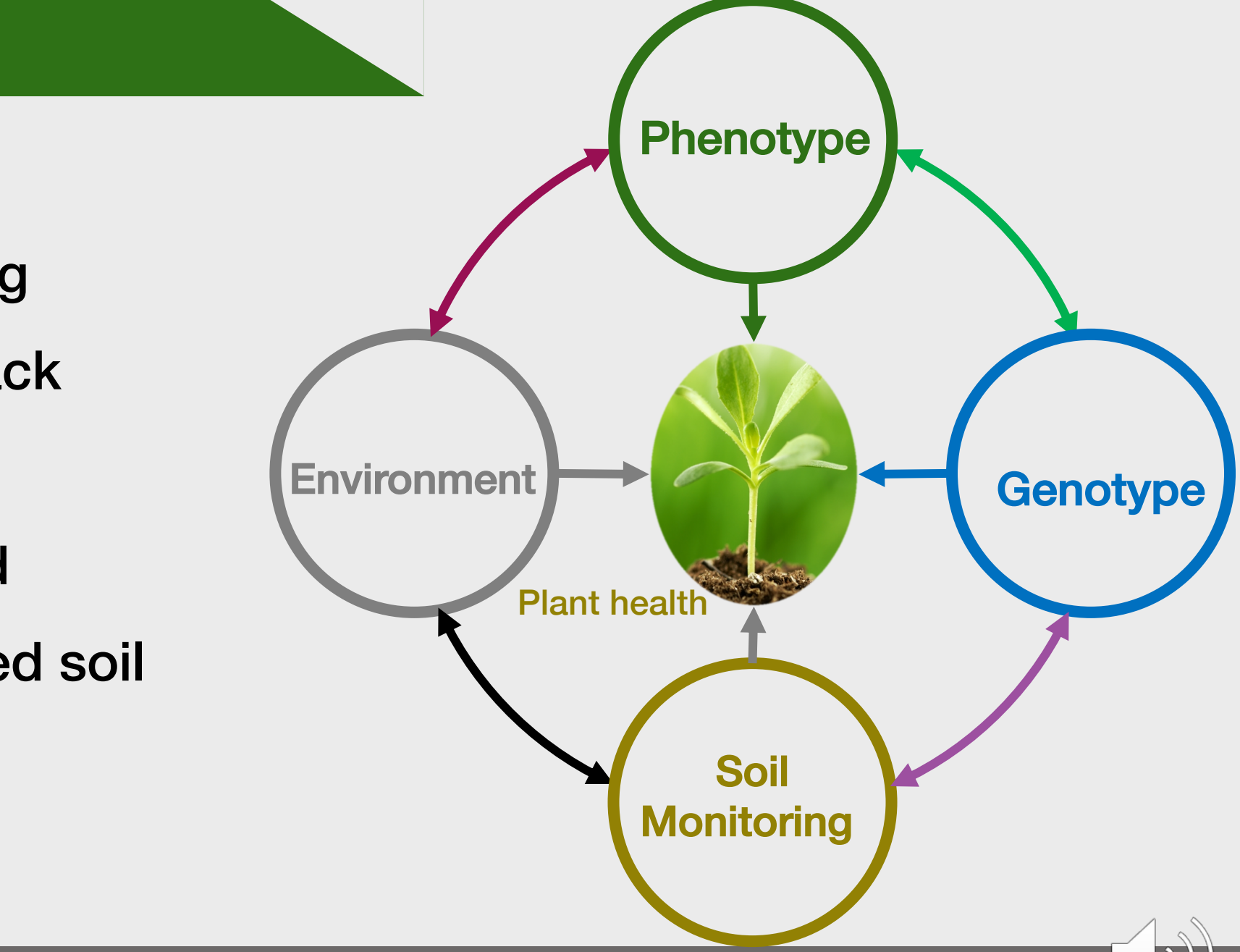
- A narrow region of soil that is directly influenced by root secretions and root microbiome
- Contains many bacteria, other microorganism,
- Proteins and sugar released by root
- Space too produce allelochemicals to control neighbors and relatives
- Plant soil feedback for growth



Lie et al. 2017

Our Approach

- Dynamic monitoring
- Continuous feedback
- In situ
- Biochemical-based
- Mapping the defined soil area



Specific Aims

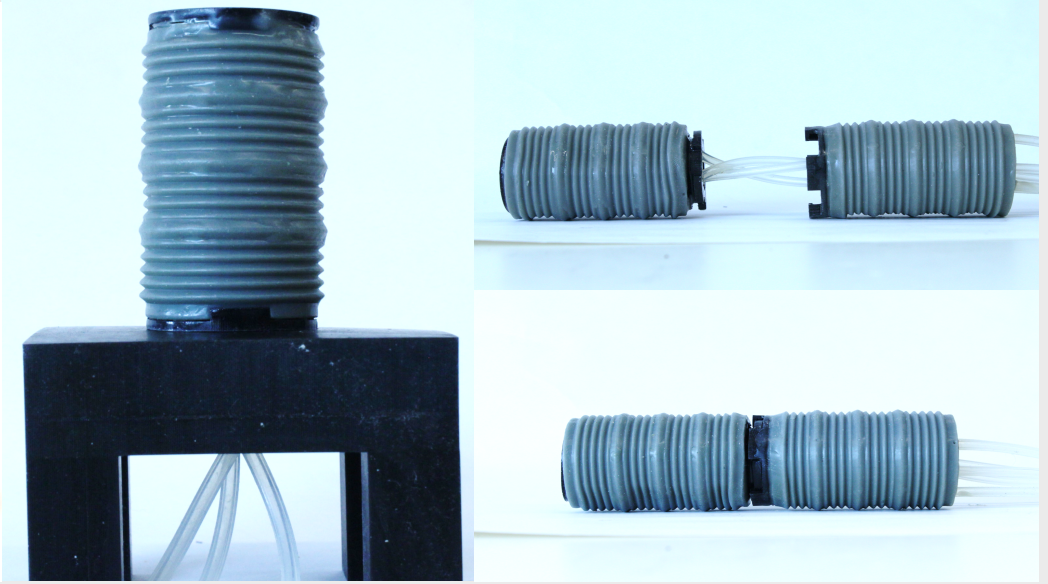
Our primary objective is to design and build a fleet of co-robots that can sense and report on plant root and soil properties at the scale of an agronomic production field.

- **AIM I.** Design and develop soil swimming robots for soil sensing of the maize plant root and its rhizosphere.
- **AIM II.** Develop the use of the soil robot collective to identify interactions between maize roots and soil water relations at critical plant development time points.
- **AIM III.** Share the impact and scientific findings of this project with the greater scientific community and public by implementing a coordinated set of activities that engage students, scientists, growers, and the public.

3D printed modules

- Tough 3D printed auger
- Multichambered and multifunctional
- 3D printed actuator
- Modular design
- Bending
- Expansion and elongation

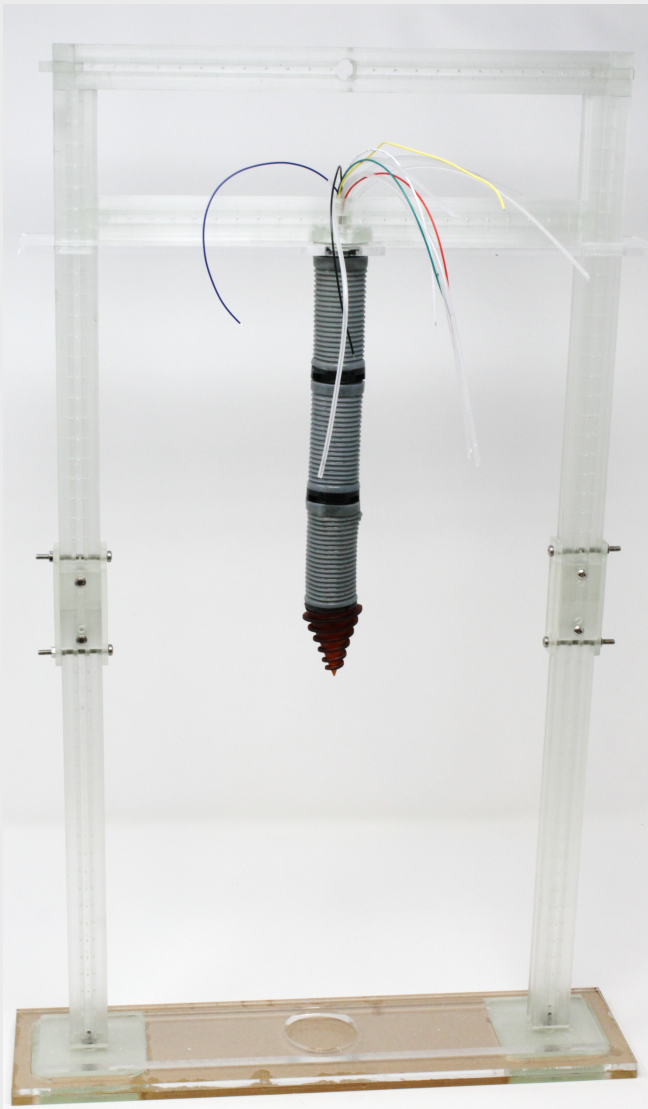
Cyanoacrylate (CE) Auger

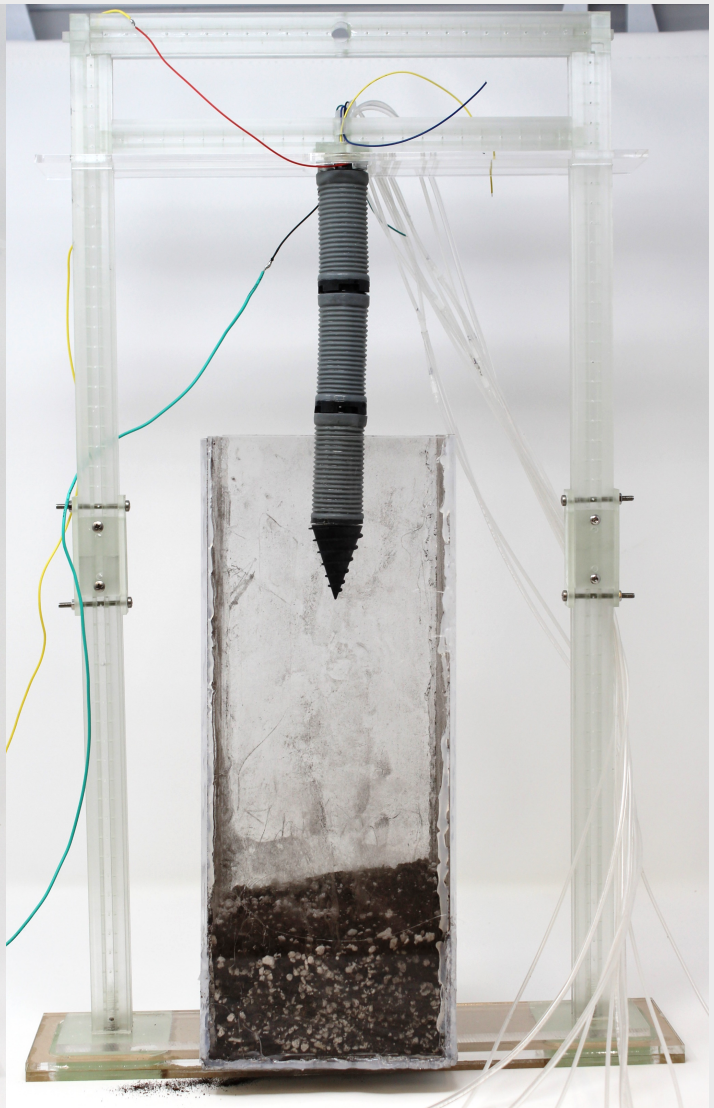


Modular soft-SIL 3D printed actuators

Current Prototype and Testing Setup

Multi-mode robot





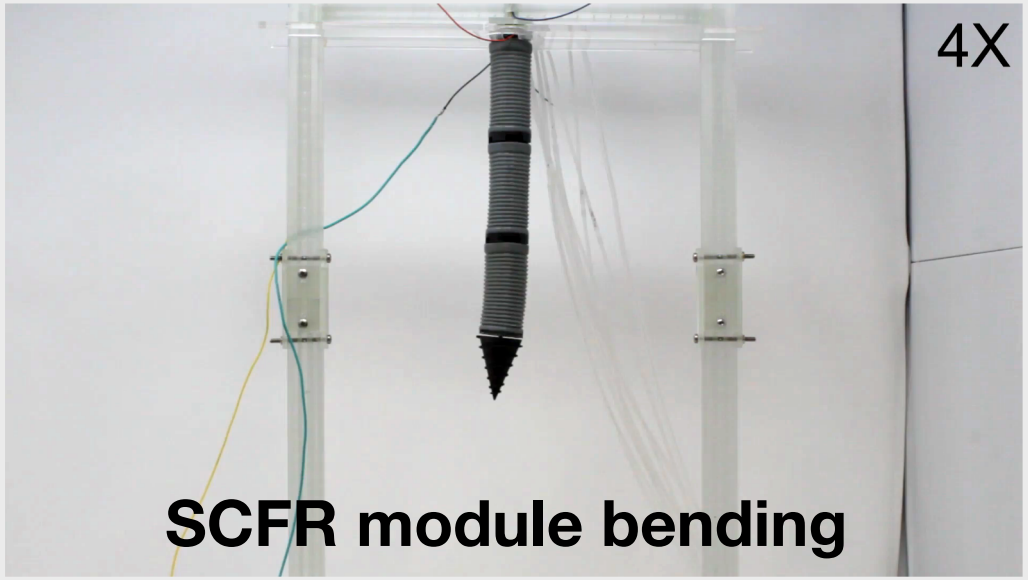
Testing setup with slider

Current results

Actuator

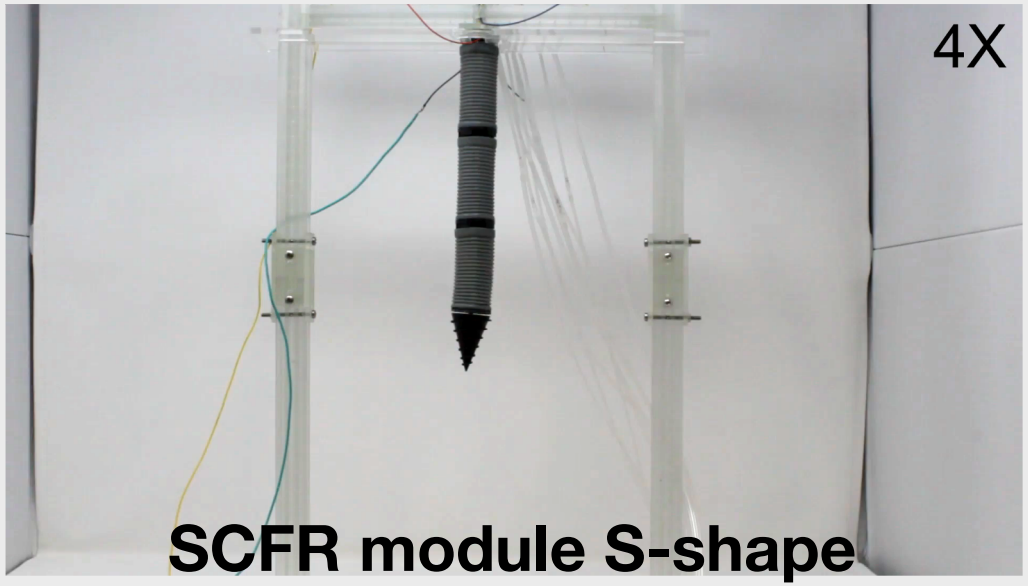
4X

Bending chamber 1



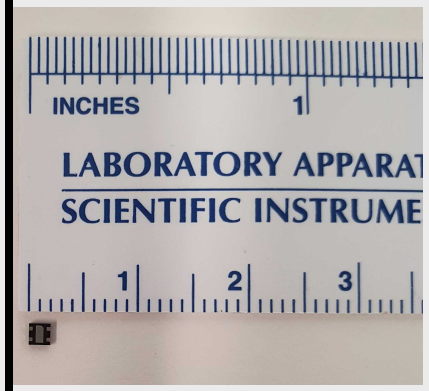
SoilBot Module

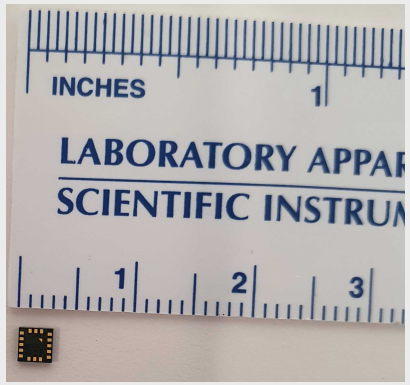
4X

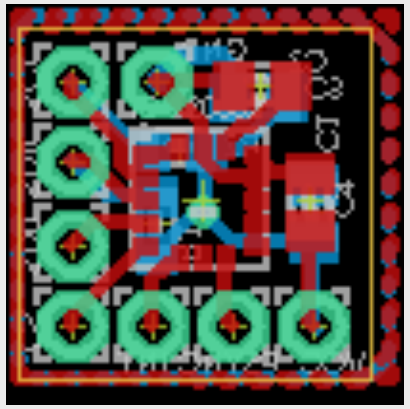


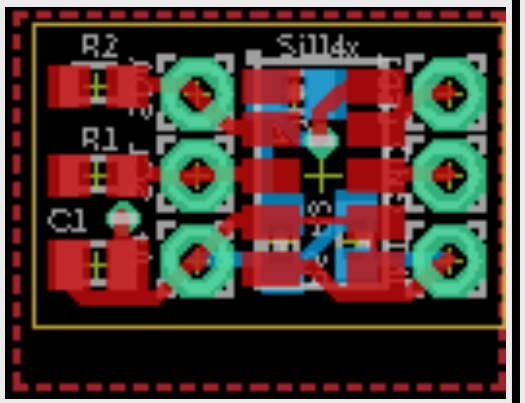
Sensor selection and design

Sensor design





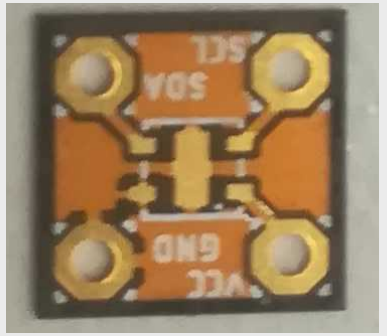


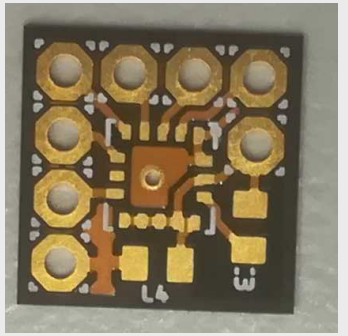


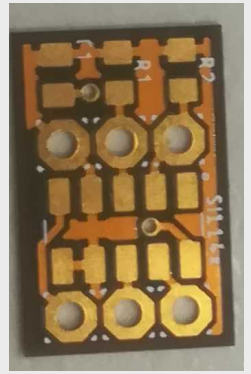
Humidity and temperature

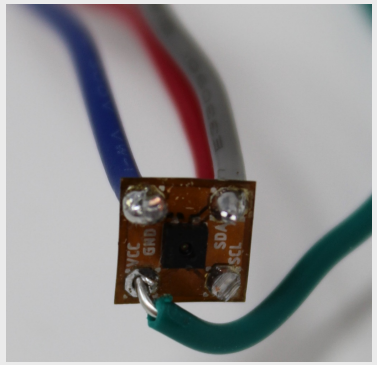
IMU

Light sensor

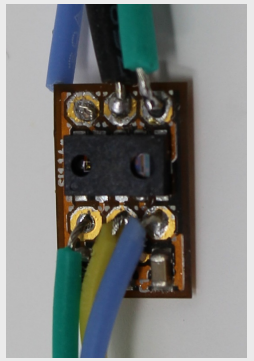








Work on process…



Humidity and temperature

IMU

Light sensor

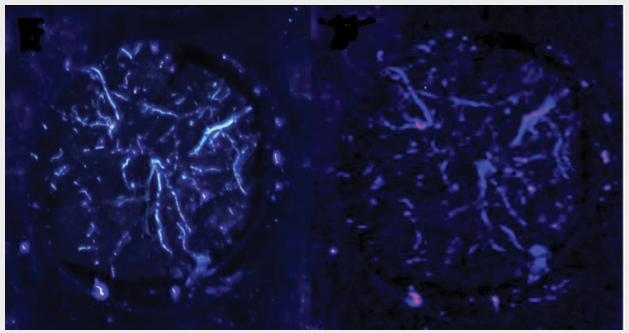
Next Steps

Soilbot design and fabrication

- Develop functional modules of SoilBot (Yr-1-2)
- Conceptualize SoilBot Carrier Field Robot (SCFR) (Yr-1)
- Develop (SCFR) (Yr-2)
- Develop control architecture (Yr 2-3)

Phenotyping

- Below-ground phenotyping (Yr-1-3)
- Experimental design and data analysis (Yr 2-3)



Thank you