DeepBloom: Open-source Plug & Play Environmental Sensing Platform for Students and Researchers

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Website: https://sites.google.com/mila.quebec/deep-bloom/home

Github Repository: https://github.com/Codify-Indoor-Ag

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Abstract

DeepBloom is an open-source sensor interface, software package, and data infrastructure suite developed to bridge the gap between technology intensive development and environmental science research in the FAES community. The project is an initiative toward making environmental data open and easily accessible for individual research as well as big data aggregation efforts for university-wide research. Through the project, we expect to foster community engagement skills to communicate data capturing needs of students, professors, and researchers across various disciplines in the faculty. To make the suite of tools easy to use, our team engaged in intensive back-end development, requiring hard skills such as, programming, User Interface (UI)/User Experience (UX) design, circuit design, package management and distribution. Our team is committed to maintaining this project as a community initiative by making all knowledge and intellectual property open-source and to strive towards achieving values of replicability, transparency, and transformation.

1. Introduction

1.1 The Challenge of Environmental Data collection

Agro-environmental and plant research often requires the collection of similar types of sensor data, such as environmental conditions, plant response, and image data over various spatiotemporal scales. These sensors are often available in either basic component forms, which require electronics interfacing and programming knowledge, or expensive handheld forms making measuring multiple sensor data simultaneously difficult and time consuming. Researchers waste valuable time outside the scope of their research to build and troubleshoot sensor systems, which can lead to handling errors and lower quality data. Our goal is to assist researchers and students in focusing on high-quality research and data interpretation by freeing them from the burden of creating complex sensor systems, saving valuable resources. The DeepBloom project aims to create a hardware and software toolkit that forms a user-friendly sensor platform for agri-environmental and plant research, allowing for easy assembly, data collection, and interface. The 3 main goals for this project are: (1) developing an open-source software that integrates environmental and plant sensors, (2) implementing data visualization, export, and user interfaces, and (3) maintaining clear documentation and code repositories for easy distribution.

1.2 Project Initiatives

The project's initiative is to address a challenge within the faculty and provide a tool that is directly transferable to on-going research projects. This helps simplify experiment design and data collection, which is exactly how the project was conceptualized between the team. Funding from SEEF has helped provide the materials needed to build a bank of sensors that are readily available for interested researchers in the FAES community who work in controlled environment agriculture (CEA) or greenhouse settings. The schematics and build guides for deploying their own system are made available at the project website. To further push our outreach, we aim to write a paper to provide standards to the diverse target audiences; plant science, horticulture, greenhouse automation and precision agriculture communities.

2. Environmental Sensing Package

DeepBloom provides users with a sensing unit that can collect and transmit environmental data to a server. The following section provides a breakdown of the components of the sensing unit, the compatible sensors and the steps to get the system working.

2.1. Sensor Selection

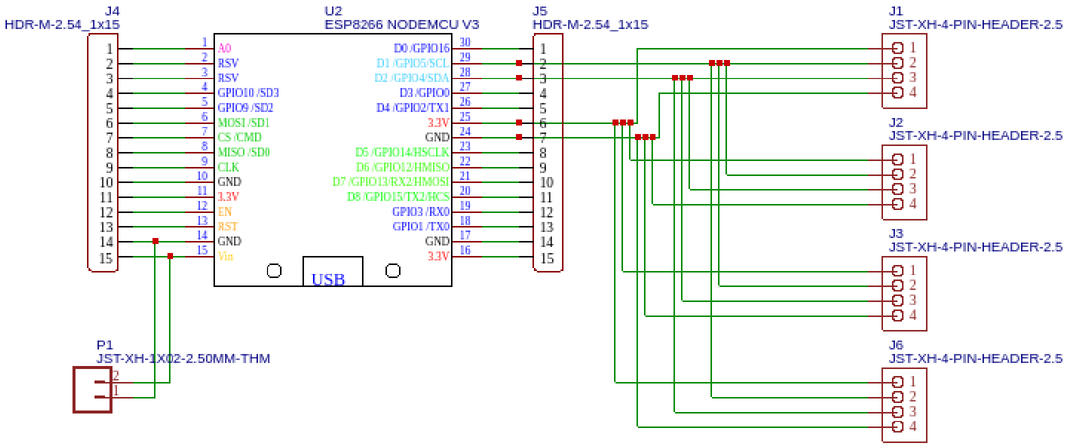
As an open source environmental sensing platform, the primary consideration for this project is the selection and implementation of low level sensing hardware. For the first iteration of the system, the team has selected sensors that correspond to 4 commonly measured parameters, which include temperature, humidity, CO_2 level and Light Intensity. As feedback is collected, the team will increase and update the list of compatible sensors. The compatible sensors are as follows:

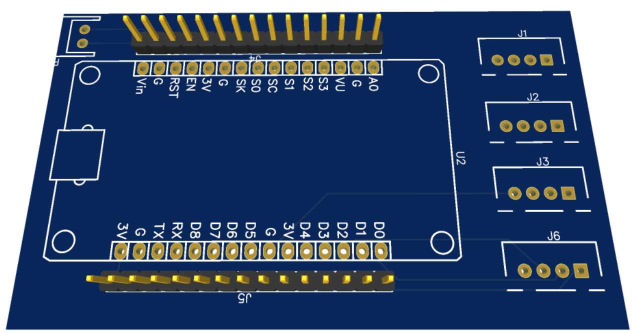
Sensor	Measurand	Comm. Protocol	# Sensor per Node
BME280	Temperature & Humidity	I^2C	1
BME680	Temperature & Humidity	I^2C	1
CSS811	CO_2 level	I^2C	1
VEMLL7700	Light Intensity	I^2C	1

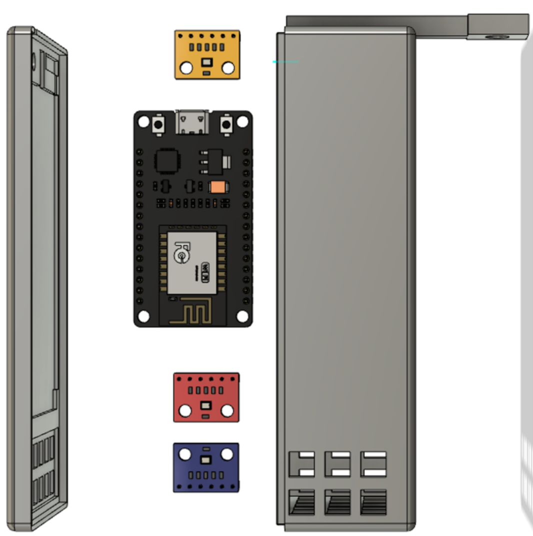
Users may select a combination of up to 4 of these sensors for each node unit for their project. This number will likely increase as the sensor interface is upgraded overtime.

2.2. Sensor Interface and enclosure

The sensor interface is the driving force for the sensing unit, and is used to collect the data from the sensors and transmit it to the database (Influxdb server). It's composed of a microcontroller and a breakout pcb board interface that is responsible for the physical connection between the microcontroller and the sensors. The microcontroller used for each node is a ESP8266 nodeMCUv3. This controller was selected for its price, availability and wifi capability. The fully connected unit is enclosed in a 3D printed box to ensure the bare electronics are protected from exposure to the environment. All interface schematics and 3D files can be found on the project website for easy DIY replication. Please note that while recommended, the pcb interface is not necessary to make sensor connection. Physical wiring or custom systems can be made for DIY users. Similarly, the enclosure unit is not necessary, and a custom enclosure can be used according to researchers' needs.



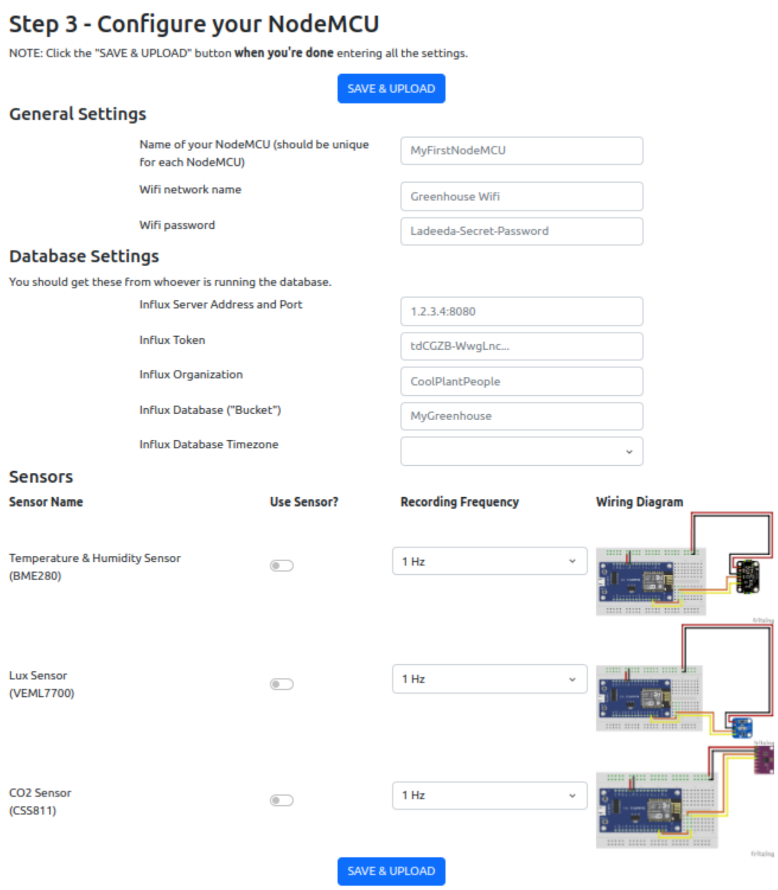




Finally, each node needs to be powered by any 5v power source (Battery, USB dongle, or custom power supply).

2.3. Sensor Setup and Software Flashing

Once the sensors for each node are selected and the physical system is ready to be deployed, the necessary software should be flashed onto the nodeMCU with the proper sensor configuration. Our team has made an easy to use web tool that does the flashing for the user and removes the usual programming hurdle associated with basic sensor components. The easy flash webtool interface can be found at:
https://codify-indoor-ag.github.io/greenhouse_webtools/flash.html
Users must simply follow the instructions on the site and the node will have the necessary driving software to collect data. Screenshots of the webtool interface are shown below.

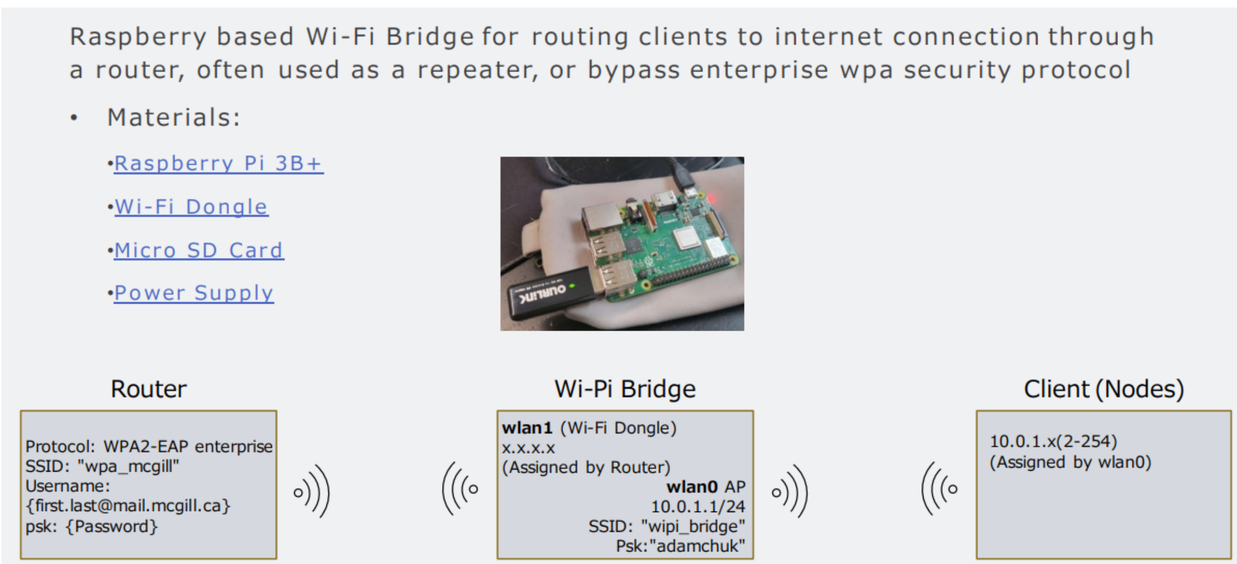


Once the software has been flashed onto the nodes, they are ready to be deployed into the experiment setting.

3. Data infrastructure

3.1 Network Interfacing

The sensing units transmit data over wifi to the designated servers. During the sensor setup explained in section 2.3, users are prompted to enter WPA credentials of the experiment site. This can be an issue, if you are using enterprise level networks, such as the one used in McGill. Users can circumvent this issue by using a personal router and connecting directly to the ethernet port and using the router's credentials during sensor setup. If an ethernet port is not available, the developers of DeepBloom have created a workaround project known as the WiPi Bridge. This method uses a raspberry pi as a wifi bridge to create a WPA network between mcgill enterprise network and the sensing units. Instructions for the setup of the units can be found here: https://github.com/Codify-Indoor-Ag/wipi-bridge-ui. Users can then use the credentials of the WiPi bridge during the sensor setup step.



3.2 Influxdb database

As of the current iteration, the database system used for this project is influxDB, a open-source time series database (TSDB). During sensor setup, established in section 2.3, users will be prompted to enter the influxDB credentials. Users can either use a pre-established influxDB set up by the DeepBloom team, which can be found on the project website, or they can set up and use their own influxDB servers (https://www.influxdata.com/influxdb/).

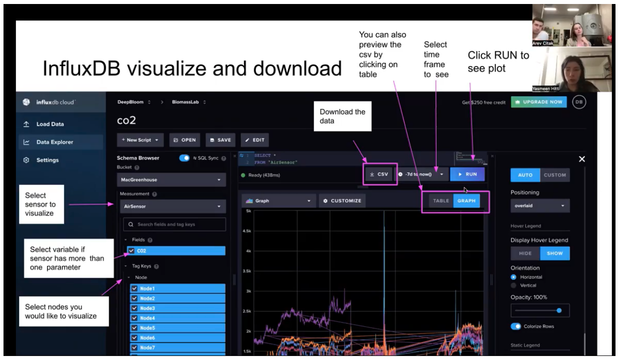
4. Active Community Projects

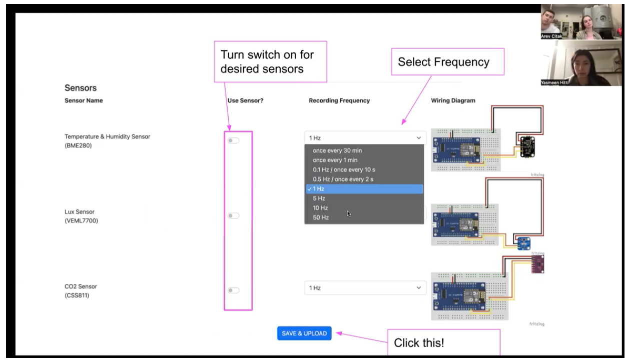
With the completion of the first usable iteration of the deepbloom platform, our team has been establishing various community efforts in order to get the project implemented by various teams in the faculty. These efforts include tutorials/office hours to teach students and faculty members how to use the system, establishing a permanent installation in the research greenhouse, and continuous feedback sessions in order to improve and maintain the project.

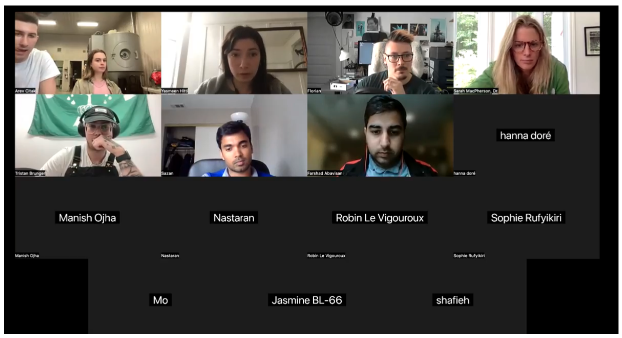
4.1. Tutorials

Two types of tutorials have been established to help students implement the DeepBloom platform into their project. The first tutorial is a hands-on soldering tutorial, to help DIY users make a system specific for their project. This tutorial is meant for beginner users with some electronics background using breadboards. This tutorial helps them upgrade from a temporary breadboard setup to a more permanent pcb setup for robust collection systems.

The second tutorial is on how to setup, interface and implement the deepbloom system. This tutorial is meant for users of any level and is a “getting started” guide. Recordings of this tutorial will be hosted on the project website and can be found here.



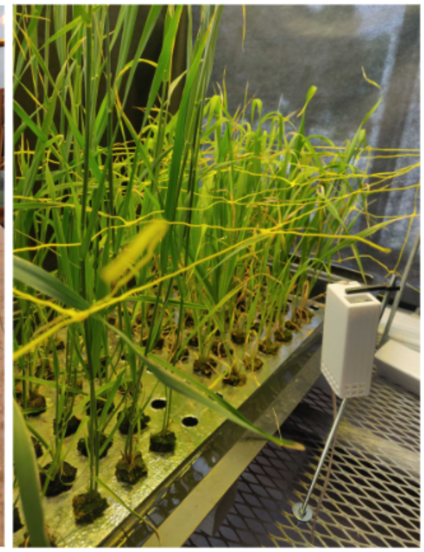




4.2. Spatial Greenhouse Trials

The first implementation of the sensing platform is located at McGill's research greenhouse. 12 units are placed throughout the greenhouse collecting temperature, humidity, CO_2 and light data. These sensors are collecting spatiotemporal data from within the greenhouse bay, and thus actively collecting information for the experiments performed on these benches. This data is available on our public DeepBloom influxDB server for any researcher to access and use. The data collected from these sensors will be used to assess greenhouse efficiency at a higher spatiotemporal resolution than the industry standard. The results will be used to write a platform paper and submitted to a journal for further project exposure.





4.3. Deepbloom Maintenance and Development

Our team is committed to maintaining and continuously improving the platform while keeping the core project open source. Multiple feedback sessions are conducted in order to gather information on further research needs, develop software to increase the number of compatible sensors and catch any bugs during usage. Our team has established office hours to answer questions. A github repository has been created to host the project's up-to-date software packages and collect issues. Finally a website has also been created to host information about the project and redirect users to the right place. This project is created and maintained by the DeepBloom team:

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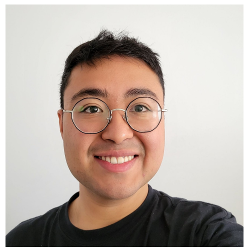

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Please consider buying us a cup of coffee! :)

5. Conclusion

The DeepBloom project has demonstrated a successful design and implementation of an open-source, user-friendly sensor platform aimed at improving the efficiency of data collection in the field of agro-environmental and plant research. The project exhibits a significant stride towards the augmentation of data accessibility and quality in these fields, reducing the technical complexities traditionally associated with sensor data collection. Our sensor platform facilitates a seamless integration of various environment-specific sensors including temperature, humidity, CO_2 level, and light intensity. Further iterations will cater to a more diverse array of sensor types, based on user feedback and emerging research requirements, ensuring the platform's continual adaptability and relevance.

In conclusion, our team aims to facilitate and improve data collection in agro-environmental and plant research. We anticipate that our platform will not only streamline existing research processes but also foster an environment conducive to knowledge exchange and learning. As we continue to support and enhance this platform, we remain dedicated to fostering a culture of open innovation, transparency, and cross-disciplinary collaboration.