Smart Wireless Ag Sensors for Measurement of Soil Water Contents

PROJECT PLAN

Team Number: 38
Client: Iowa State University – Research Department
Adviser: Dr. Liang Dong
Team Members/Roles:
Colin Cox – Project Manager – Software Team
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1 Introductory Material

1.1 ACKNOWLEDGEMENT

We would like to thank the following groups/people for their help throughout this project.

- Iowa State University Research Departments
    - Electrical Engineering
    - Agronomy
- Leland Harker
- Dr. Liang Dong, Dr. Azahar Ali and students (Grad and PhD.)
    - Xinran Wang
    - Yuncong Chen

1.2 PROBLEM STATEMENT

As the population of the world increases we need to account for feeding everyone. The problem that the research department is facing is how to improve crop yields within agriculture by looking at the differences between genetics of plants and the chemical levels within plants and soil effected by fertilization. To get this information the electrical and agriculture research departments have teamed together and developed plant and soil sensors to collect data for analysis.

Our team is working to improve these sensors, to allow for enhanced data collection and interpretation. We are designing and developing new sensors to be used out in the fields, while creating an updated user interface to access and store data in. There are several changes for improving the current design of the sensors, and they are categorized as follows:

1. Improving the control box. Looking at the components and housing.
2. Develop more sensors for communication testing we currently only have one prototype of each plant and soil sensor.
3. Advancing the application used for collecting data. A commercial app is currently being used for data analysis, and only one sensor can be analyzed at a time.

These three main general change areas to our project can be broken into corresponding solutions for each problem.

1. For the control box, we would like to decrease the size down to ¼ of what it is currently. This will improve efficiency and reducing power consumption.
2. Creating more prototypes is our solution to the second problem listed above, and our plan is to manufacture 10 sensors and have them all communicating with the application out in the fields.

3. Lastly, our group plans on making our own application that can allow for data extraction and analysis of all the soil and plant sensors simultaneously. Improving the user interface and adding useful functions like a data plot to show trends throughout the season.

In making these improvements the team can find out what would be the best type of crops to plant in different environments and how much fertilizer will be needed throughout the season. Ultimately this research can be used to help farmers grow better crops increasing their yields allowing for more food and less waste.

1.3 OPERATING ENVIRONMENT

Our plant and soil sensors will have an operating environment of either a corn or soybean field. With that in mind, they need to be waterproof in order to withstand rain, be able to withstand relatively extreme temperature swings depending on farming location, and be resistant to insects or animals within the fields. Additionally, the sensors will be out in the field for anywhere from a few days to a few weeks or months, so sustainability is a key component that we intend to address with a rechargeable battery and solar panels.

1.4 INTENDED USERS AND INTENDED USES

The intended users for our sensors in the near future are those researching crop yields. This will begin with researchers in the College of Agriculture at Iowa State University and eventually be outsourced to other agricultural companies.

The plan is to then have our product used by farmers in order to give them the technology necessary to conduct soil sample testing on their own, rather than having to ship soil out for testing to a third-party company.

We need to make sure that our sensors meet the standards of both intended users, we plan on achieving this by upkeeping and improving the accuracy of the sensors and data collection while improving the durability and longevity of the control boxes. Also we are allowing for easy instillation into the fields.

1.5 ASSUMPTIONS AND LIMITATIONS

Assumptions:

1. Design sensors specifically for research purposes
2. Each control box will have one sensor. These sensors will be interchangeable in order to test plants and soil.
3. Design a network consisting of at least 10 sensors.

Limitations:

1. The end product needs to be ¼ of original size

2. The system must operate under moderate temperature changes (-20 Fahrenheit to 120 Fahrenheit)
3. Project budget cannot exceed $2,000
4. Battery life must be up two weeks minimum

1.6 EXPECTED END PRODUCT AND OTHER DELIVERABLES

Soil and Plant Sensors

Two new sensor designs that incorporate a circular design that will make the fabrication process more efficient.

User Interface

User interface that can be accessed from a mobile device for easy transfer and view of data on sensors.

Mesh Network Capabilities

The software and hardware of the sensor box must support a mesh style network so that multiple sensors can connect to a collection point without additional infrastructure.

Control Box

The size of the control box is to be reduced to a quarter of its current size. In doing so the electronic components also have to be reduced in order to fit in the new control box. Smaller circuit boards, and battery for each box.

2 Proposed Approach and Statement of Work

2.1 FUNCTIONAL REQUIREMENTS

Functional Requirements:

- Sensor box ¼ of original size
- Battery life up to two weeks
- Can withstand temperatures ranging from −20 Fahrenheit to 120 Fahrenheit
- Portable
- Takes accurate measurements of phosphate/nitrogen/potassium concentration
- Waterproof and insect resistant

2.2 CONSTRAINTS CONSIDERATIONS

Nonfunctional requirements:

1. Easy to navigate software interface

2. Efficient networking
3. Cheap for consumers
4. Not harmful to environment (little to no emissions)

Our project will follow standard protocols developed by IEEE, the Code of Ethics. These protocols are applicable to our project as we are working in a team as well as with a client and potentially the public. All decisions will be made ethically and morally in order to ensure proper conduct.

2.3 TECHNOLOGY CONSIDERATIONS

We plan to design the PCB for the sensors to be more circular in shape. Our intuition tells us that this should be a suitable solution to our current sensors problems. The strengths to our proposed solution are the removal of the "step up" problem and the easier deposition of silver on our PCB.

2.4 SAFETY CONSIDERATIONS

Our group has received training on using the PCB mill and soldering as to avoid any injuries that could occur. We will also have the safety of the public in mind when it comes to our end product as farmers and researchers will be using the devices regularly.

2.5 PREVIOUS WORK AND LITERATURE

Currently these sensors are the first of their kind so all previous work is transferred to us through conversations with Dr. Liang Dong and his graduate students.

2.6 POSSIBLE RISKS AND RISK MANAGEMENT

Some possible setbacks currently would be: lack of resources for previously designed circuit, and the sensor re-design process.

2.7 PROJECT PROPOSED MILESTONES AND EVALUATION CRITERIA

Our group is split into three groups: sensors, control box, and application. The proposed milestones are listed below:

Sensors:

1) Fabricate a working soil sensor. - To test this, we will continually check the conductivity of the sensor throughout the fabrication process.
2) Test sensor in soil water with old control box. - To test this, we will use an old sensor and control box on the same soil water as the new sensor and control box and compare the results.

Control Box:

1) Reduce the size of the control box PCB. - Test the new PCB design against the old design and compare the results.
2) Reduce the size of other components in control box. - Assemble the components of the new control box and test it alongside the old control box and compare the results.
3) Print a new box for the new control box components.

Application:

1) Create software for application, improving data collection and user interface.
2) Test communication of sensors with application.
3) Test for mass quantities of data collection and communication between 10 sensors.

2.8 PROJECT TRACKING PROCEDURES

Our group will be tracking progress via our timeline as well as using websites such as GitLab and CyBox. We will also be meeting with our client biweekly and corresponding graduate students on a need-to-meet basis.

2.9 OBJECTIVE OF THE TASK

Our teams task is to improve the sensors within the following aspects:

- Fabrication of the sensors
- Efficiency and size of the control box
- Updated application with data collection
- Communication between sensors and app (advance software)

2.10 TASK APPROACH

We split our team into three groups: sensors, control box and application development.

2.11 EXPECTED RESULTS AND VALIDATION

3 Estimated Resources and Project Timeline

3.1 PERSONNEL EFFORT REQUIREMENTS

Name	**Task**	**Explanation**
Colin Cox	Software / Application	
Jarrod Droll	Sensors	

Rachel Hoke	Sensors	
Wage Miller	Control Box	
Scott Rowekamp	Software / Application	
Tyler Thumma	Control Box	

3.2 OTHER RESOURCE REQUIREMENTS

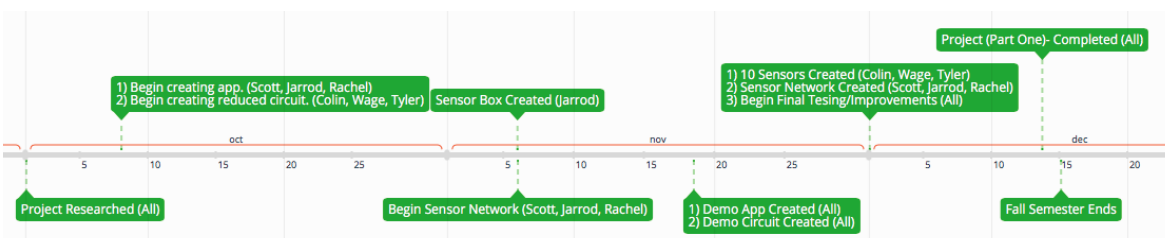
The resources required for this project include:

- Circuit design components (Resistors, capacitors, op-amps, etc.).
- Circuit design software (Multisim, Ultiboard).
- Chemical solutions necessary for sensor development.

3.2 FINANCIAL REQUIREMENTS

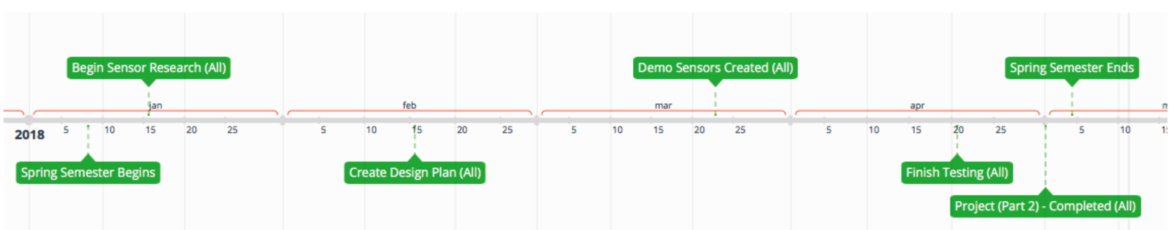
According to our client our project has a budget of $2,000 to work with.

3.3 PROJECT TIMELINE



Semester 1:

Semester 2:



Throughout the year we will be focusing on different aspects of the project. We have dedicated our first semester towards learning, designing, and testing the sensors. Once we have completed and finalized our new design plan we will begin work on implementing it within the second semester building multiple sensors and testing them in the field.

4 Closure Materials

4.1 CONCLUSION

Our team is focused on improving the sensors in order to increase their abundance in crop yield research, by doing so researchers will be able to develop higher quality seeds and knowledge on effects of fertilizer. We plan on accomplishing many of our goals for advancing and improving our system, while grow stronger as a team to ensure our clients a successful product. We will accomplish this through research and collaboration with our team and advisors throughout the project timeline.

4.2 REFERENCES

4.2 APPENDICES