Smart Backpack Sprayer for Small-Scale Agriculture Applications
Design Document

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sdmay20-53

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Executive Summary

Development Standards & Practices Used

We do not currently have any circuit design requirements, as we plan on using Arduino. We will follow the ISO/IEC 12207 systems and software development standards. Lastly, we will follow the IEEE 1016 digital design standards. We will follow these standards for each component of our project.

Summary of Requirements

- The system shall collect flow rate data
- The system shall collect GPS data
- The system shall record substance in use
- The system shall record compass data
- The hardware shall use a flow sensor with accuracy to 10% of the duty cycle
- The hardware shall use a GPS sensor with accuracy to 3 meters
- The hardware shall have a battery life at least 3 hours.
- The hardware shall be mountable inside backpack sprayer
- The hardware shall package data in JSON format
- The hardware shall be able to send data using Bluetooth
- Data shall be collected in 1 second intervals
- Data collection shall be time-stamped with 24 hour time format
- The application shall be functional on iOS
- The application shall collect data using bluetooth
- The application shall be able to parse data in JSON format
- The application shall map GPS data using Mapbox
- The application shall report substance being sprayed for each spraying event
- The application shall include flow rate in report of spraying, for each received packet
- The application shall include functionality to save spraying events
- The system shall be waterproof
- The system shall be operable in temperatures between 0-100C
- The system shall be under 30 pounds
- The system shall be wearable on one's back

Applicable Courses from Iowa State University Curriculum

- AGRON 160 - This class covers water resources and how they can be affected. Our project would help reduce chemical runoff, and material learned in this class can be useful when dealing with the environmental aspects of the project.
- COMS 309 - Working on a semester long small group project helped us develop good team practices and better understand how to work together effectively. Additionally, the material covered agile practices we will be utilizing throughout this project.
- CPRE 288 - Our project will be combining a variety of sensors and a microcontroller, similar to the process that we went through in the lab portion of this course. We can build off of the material learned to more productively use the sensor data.
- EE 201/230 - The basic circuitry learned in these classes will be useful in our project for connecting the Arduino to power and other components.

New Skills/Knowledge acquired that was not taught in courses

List all new skills/knowledge that your team acquired which was not part of your Iowa State curriculum in order to complete this project.

Introduction

Acknowledgement

Intellispray - Hardware and Financing

“If a client, an organization, or an individual has contributed or will contribute significant assistance in the form of technical advice, equipment, financial aid, etc, an acknowledgement of this contribution shall be included in a separate section of the project plan.”

Problem and Project Statement

This project is modifying a backpack sprayer used for weed killers, bug spray, or similar chemicals on small farms and acreages. Commercial sprayers currently do not offer a "smart" option, making it difficult for users to keep track of product placement information. We will develop an iOS application, paired with an Arduino device inside the backpack, to meet project requirements and provide users with spray information. This application will store location, flow rate, time of coverage, and other relevant data. The purpose of our project is to simplify the lives of our client base and reduce waste caused by excess chemical coverage.

Operational Environment

The operational environment for this project is an agricultural environment. This means that the solution will be exposed to rain, wind, dirt, dust, chemicals, and other elements. The solution must be robust such that it will function in a wide variety of conditions.

Requirements

Functional Requirements

- Read sensor data
    - Includes GPS location, rate of application
- Backpack sprayer must communicate with mobile app
- App should analyze data
- Create map of spray amount and time of application

Economical Requirements

- Initial Budget of $750
- They will probably provide us with what we need
    - Ask them and they will provided
    - Examples:

        - Subscriptions
        - Hardware
        - Software
        - etc.

Non-Functional Requirements

- Portable
    - Size and Weight
- Scalable
- Reliable
- Intuitive to Use

Environmental Requirements

- Waterproof: IP67
- Signal Range: 10m
- Temperature: -25 ~ 100 °C
- Altitude: 0 ~ 2500m
- Wind Speed: below 25 km/h

Intended Users and Uses

The intended user is one that works in a small scale agricultural environment. The user has a need to spray the land somewhat frequently, where learning about each spray application would be beneficial in order to maximize efficiency of spraying and to learn from previous applications. The use of this product is for a small scale operation, so that the battery life and amount of spray is sufficient to cover the desired area. The user will typically wear the product while using it.

Assumptions and Limitations

Assumptions

- Limited Number of Users
- The end product will be used in spring and summer
- The end product will not be used in the rain
- The end product will be self contained inside of the backpack
- Then end product will measure in imperial and metric units

Limitations

- GPS Measurement Accuracy within a few feet/ a meter
- Flow Rate Measurements based off of what the sensors allow

- Battery-life must meet Realistic usage times
- Expenses are within the $750 initial budget

"– Two separate lists, with a short justification as needed.

– Extremely important, as it can be one of the primary places where the client can go to determine if the end product will meet their needs.

– Examples of assumptions: The maximum number of simultaneous users/customers will be ten; Blue is the best background color and will be used; The end product will not be used outside the United States.

– Example of limitations: The end product shall be no larger than 5"x8"x3" (client requirement); The cost to produce the end product shall not exceed one hundred dollars (a market survey result); The system must operate at 120 or 220 volts and 50 or 60 Hertz (the most common household voltages worldwide).

– For limitations, include tests not performed, classes of users not included, budget/schedule limitations, geographical constraints, etc. "

Expected End Product and Deliverables

These tie in with the goals. What deliverables are necessary to meet the goals outlined in the introduction?
List the end product and any other items, along with a brief description, that will be delivered to the client prior to the end of the project.
– If the end product is to be commercialized, the description shall be of the commercialized end product.
– It shall be in the form of a technical product announcement, as opposed to a product advertisement, and shall not include a list of technical specifications.
– Any other items that will be delivered to the client shall also be included and described unless their definition and description are obvious.
– Examples might include a household power supply to eliminate the need for batteries, a user's manual, or other project reports.
– There shall be at least a one-paragraph description for each item to be delivered.
– Delivery dates shall also be specified.
The deliverables are a backpack sprayer solution and a mobile application. These two need to be able to communicate together and create the "smart" backpack sprayer.

The backpack sprayer shall be a portable/wearable solution that will allow the user to spray substances on the small-scale agricultural operation. This will also include sensors that are able to collect GPS coordinates, directional data, and flow data from the sprayer. An Arduino housed within the backpack will be a component of this solution. The arduino will use Bluetooth to send data to the user's mobile device.

The mobile application will be developed for iOS. It shall be able to receive data from the smart backpack using Bluetooth and then parse this data and represent it in a clear and effective way to the user. This will include a map of the locations sprayed as well as the flow rate at each location, the time of the spraying, direction of where the spray was directed, and what was being sprayed from the backpack. The application will be able to record historical data from previous sprays.

Specifications and Analysis

Proposed Design

Include any/all possible methods of approach to solving the problem:
– Discuss what you have done so far – what have you tried/implemented/tested, etc?
– We want to know what you have done
• Approach methods should be inclusive of functional and non-functional requirements of the project, which can be repeated or just referred to in this section
If your project is relevant to any standards (e.g. IEEE standards, NIST standards) discuss the applicability of those standards here

Design Analysis

– Discuss what you did so far
– Did it work? Why or why not?
– What are your observations, thoughts, and ideas to modify or continue?
– If you have key results they may be included here or in the separate "Results" section
-Highlight the strengths, weakness, and your observations made on the proposed solution.

Development Process

Discuss what development process you are following with a rationale for it – Waterfall, TDD, Agile. Note that this is not necessarily only for software projects. Development processes are applicable for all design projects.

Design Plan

Describe a design plan with respect to use-cases within the context of requirements, modules in your design (dependency/concurrency of modules through a module diagram, interfaces, architectural overview), module constraints tied to requirements.

Statement of Work

Previous Work and Literature

Include relevant background/literature review for the project
- If similar products exist in the market, describe what has already been done
- If you are following previous work, cite that and discuss the advantages/shortcomings
- Note that while you are not expected to "compete" with other existing products / research groups, you should be able to differentiate your project from what is available

Detail any similar products or research done on this topic previously. Please cite your sources and include them in your references. All figures must be captioned and referenced in your text.

Technology Considerations

Highlight the strengths, weakness, and trade-offs made in technology available.
Discuss possible solutions and design alternatives

Task Decomposition

In order to solve the problem at hand, it helps to decompose it into multiple tasks and to understand interdependence among tasks.

Possible Risks and Risk Management

Include any concerns or details that may slow or hinder your plan as it is now. These may include anything to do with costs, materials, equipment, knowledge of area, accuracy issues, etc.

Project Proposed Milestones and Evaluation Criteria

What are some key milestones in your proposed project? Consider developing task-wise milestones. What tests will your group perform to confirm it works?

Project Tracking Procedures

What will your group use to track progress throughout the course of this and next semester?

Expected Results and Validation

What is the desired outcome?
How will you confirm that your solutions work at a High level?

Project Timeline, Estimated Resources, and Challenges

Project Timeline

- Design Documentation V1- Due Oct 8, 2019
    - Weekly Reports Interspersed throughout Semester
- Hardware Delivery (Hopefully By) - Oct 9, 2019
- Assembling Hardware - Oct 23, 2019
- Design Documentation V2 - Due Oct 29-31, 2019
- Software Completion - Nov 16, 2019
- Integration - Nov 2, 2019
- Design Documentation V3 (Final For Semester 1) - Due Dec 3-5, 2019
- Prototype for Software and Hardware - Due Dec 09, 2019

Feasibility Assessment

Realistic projection of what the project will be. State foreseen challenges of the project.

Personnel Effort Requirements

Include a detailed estimate in the form of a table accompanied by a textual reference and explanation. This estimate shall be done on a task-by-task basis and should be based on the projected effort required to perform the task correctly and not just “X” hours per week for the number of weeks that the task is active

Other Resource Requirements

Identify the other resources aside from financial, such as parts and materials that are required to conduct the project.

Financial Requirements

If relevant, include the total financial resources required to conduct the project.

Testing and Implementation

Testing is an extremely important component of most projects, whether it involves a circuit, a process, or a software library
Although the tooling is usually significantly different, the testing process is typically quite similar regardless of CprE, EE, or SE themed project:
1. Define the needed types of tests (unit testing for modules, integrity testing for interfaces, user-study for functional and non-functional requirements)
2. Define the individual items to be tested
3. Define, design, and develop the actual test cases
4. Determine the anticipated test results for each test case 5. Perform the actual tests
6. Evaluate the actual test results
7. Make the necessary changes to the product being tested 8. Perform any necessary retesting
9. Document the entire testing process and its results
Include Functional and Non-Functional Testing, Modeling and Simulations, challenges you've determined.

Interface Specifications

– Discuss any hardware/software interfacing that you are working on for testing your project

Hardware and Software

- Indicate any hardware and/or software used in the testing phase
- Provide brief, simple introductions for each to explain the usefulness of each

Functional Testing

Examples include unit, integration, system, acceptance testing

Non-Functional Testing

Testing for performance, security, usability, compatibility

Process

- Explain how each method indicated in Section 2 was tested
- Flow diagram of the process if applicable (should be for most projects)

Results

– List and explain any and all results obtained so far during the testing phase

- – Include failures and successes
- – Explain what you learned and how you are planning to change it as you progress with your project
- – If you are including figures, please include captions and cite it in the text

• This part will likely need to be refined in your 492 semester where the majority of the implementation and testing work will take place

-Modeling and Simulation: This could be logic analyzation, waveform outputs, block testing. 3D model renders, modeling graphs.

-List the implementation Issues and Challenges.

Closing Material

Conclusion

Summarize the work you have done so far. Briefly reiterate your goals. Then, reiterate the best plan of action (or solution) to achieving your goals and indicate why this surpasses all other possible solutions tested.

References

This will likely be different than in project plan, since these will be technical references versus related work / market survey references. Do professional citation style(ex. IEEE).

Appendices

Any additional information that would be helpful to the evaluation of your design document.

If you have any large graphs, tables, or similar that does not directly pertain to the problem but helps support it, include that here. This would also be a good area to include hardware/software manuals used. May include CAD files, circuit schematics, layout etc. PCB testing issues etc. Software bugs etc.