Smart Water Leak Shutoff Valve

Design Document

sdmay21-11
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Revised: 10/4/2020 v1

Executive Summary

Development Standards & Practices Used

List all standard circuit, hardware, software practices used in this project. List all the Engineering standards that apply to this project that were considered.

Summary of Requirements

List all requirements as bullet points in brief.

-Shutoff Valve

-Android Application

-Control Shutoff valve with Android Application

-Wifi connectivity through Arduino

Applicable Courses from Iowa State University Curriculum

List all Iowa State University courses whose contents were applicable to your project.

SE	CprE	EE
CS 309	CprE 288	
Cs 228		
CS 227		
CS 319		
CS 363		
SE 329		

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.

Machine Learning

Embedded Systems

Establishing communication between Android app and arduino

Getting variables from a user's system, such as their GPS location and timezone

Some basic plumbing knowledge

Table of Contents

List of figures/tables/symbols/definitions (This should be the similar to the project plan)

1 Introduction

1.1 Acknowledgement

We would like to thank Dr. Cheng Huang for being our advisor for this project. His proposal provides an applicable, hands-on opportunity to combine hardware and software components into an end product that can be utilized by many people today. We appreciate his insights and dedication to keep us on track to produce an efficient and effective product.

1.2 Problem and Project Statement

For many homeowners or property managers, water damage is a significant concern and can be an expensive problem to fix, with one of the most frequent reasons for flood damage being leaking or burst pipes. Current market available options to monitor and control water flow are too expensive or lack additional functionality for most homeowners to consider purchasing. The goal for this project is to develop a low-cost water shutoff valve with the ability to monitor water flow in order to prevent and protect against these types of damages. The product should be able to: measure the flow of water through the water line, connect to the internet for real-time water control and monitoring, and provide smart features such as text alerts and an automatic shutoff mode.

With this project, we hope to provide a means to prevent water damage, while keeping the component cost of the product around $200. By being able to detect when abnormal water usage occurs, our product will be able to alert the homeowner and shut off the valve to prevent further damage. The shut-off valve would be a good preventative investment for homeowners, while also being market competitive by being cheaper than other available options. We hope to deliver a complete system with internet-connected hardware that can monitor water flow, shut off the water valve, and can be controlled via a user friendly smartphone app that can also monitor the hardware and control the water shutoff valve.

1.3 Operational Environment

Our hardware components for the project will be installed by the main waterline for a building. These areas can be damp and prone to dust. The inside component will be exposed to water. The app would be expected to be used on most mobile devices in a place that has internet connection.

1.4 Requirements

- Total hardware components should stay within a $200 goal
- Hardware should be able to be installed in a home or business setting
- Hardware should be able to monitor the flow of water through waterline and send the data to be stored on a server
- Hardware should be able to shut off the flow of water through the waterline
- App should be able to communicate with the hardware to open and close the water valve
- App should allow users to view history of waterflow
- App should allow users to monitor current waterflow
- App should be responsive and easy to use

- App should allow users to list times when the valve should be automatically shut when water is detected

1.5 Intended Users and Uses

The intended users for this product are homeowners and other property owners. Water damage can be expensive to repair and can cause structural damage to buildings. This product will supply property owners with a cost-efficient way to prevent water damage and monitor water usage. Depending on the most effective solution, the product will be able to be used by people with no or limited plumbing knowledge.

1.6 Assumptions and Limitations

– 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.

Assumptions:

-Users have access to a mobile device with internet connectivity

-Users have basic plumbing knowledge to install the valve by themselves

-Only one user can be logged into the account at once

-Users have internet connection for hardware to connect to

-Users have some basic knowledge of plumbing

Limitations:

-Product should cost less than $250

-Should be small enough to fit wherever the main water pipe is in the household

-Operates at common household voltages

-Depending on most effective solution, some knowledge of plumbing may be required

1.7 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.

Hardware System - internet connected water shutoff valve with waterflow connection. Multiple options available with recommendations based on the user's knowledge of plumbing. Delivered by May 2021.

Mobile App - User friendly mobile application that allows for manually shutting off water through the water valve. Delivered by May 2021.

What do you guys think of this next one?

Installation Guide - Manual for users to install the hardware system for the shutoff valve Delivered by May2021

2 Project Plan

2.1 Task Decomposition

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

Planning

Prototyping

Development

Testing

User Feedback

2.2 Risks And Risk Management/Mitigation

Consider for each task what risks exist (certain performance target may not be met; certain tool may not work as expected) and assign an educated guess of probability for that risk. For any risk factor with a probability exceeding 0.5, develop a risk mitigation plan. Can you eliminate that task and add another task or set of tasks that might cost more? Can you buy something off-the-shelf from the market to achieve that functionality? Can you try an alternative tool, technology, algorithm, or board?

Arduino loses connection to internet

App crashing

Software compatibility

Login information getting compromised

Short Circuiting

Funding gets cut

Deadline gets moved back/forward

2.3 Project Proposed Milestones, Metrics, and Evaluation Criteria

What are some key milestones in your proposed project? It may be helpful to develop these milestones for each task and subtask from 2.1. How do you measure progress on a given task? These metrics, preferably quantifiable, should be developed for each task. The milestones should be stated in terms of these metrics: Machine learning algorithm XYZ will classify with 80% accuracy; the pattern recognition logic on FPGA will recognize a pattern every 1 ms (at 1K patterns/sec throughput). In an agile development process, these milestones can be refined with successive iterations/sprints. ML accuracy target might go up to 90% from 80%.

Machine learning algorithm to detect unwanted water flow will classify with 80% accuracy; the pattern recognition logic on water usage

System sends data updates at 5 minute intervals with 90% accuracy.

2.4 Project Timeline/Schedule

• A realistic, well-planned schedule is an essential component of every well-planned project

• Most scheduling errors occur as the result of either not properly identifying all of the necessary activities (tasks and/or subtasks) or not properly estimating the amount of effort required to correctly complete the activity

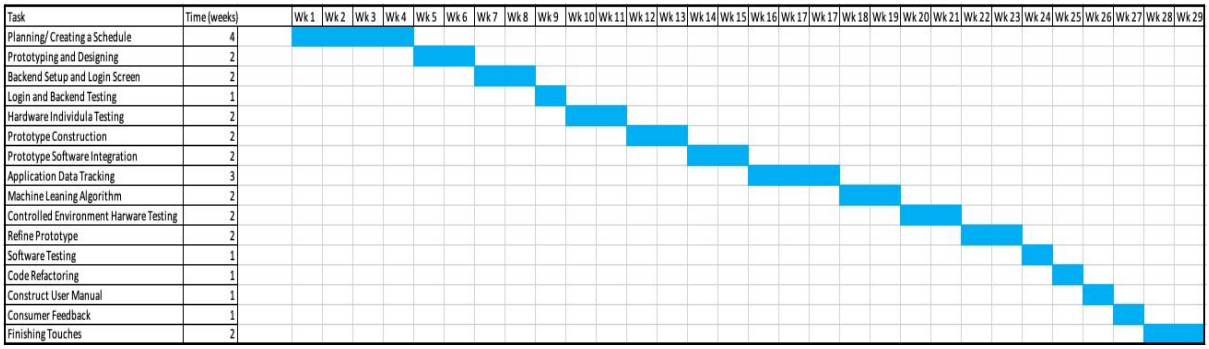
• A detailed schedule is needed as a part of the plan:

– Start with a Gantt chart showing the tasks (that you developed in 2.1) and associated subtasks versus the proposed project calendar. The Gantt chart shall be referenced and summarized in the text.

– Annotate the Gantt chart with when each project deliverable will be delivered

• Project schedule/Gantt chart can be adapted to Agile or Waterfall development model.

How would you plan for the project to be completed in two semesters? Represent with appropriate charts and tables or other means.



Task	Time (weeks)
Planning/ Creating a Schedule	4
Prototyping and Designing	2
Backend Setup and Login Screen	2
Login and Backend Testing	1
Hardware Individula Testing	2
Prototype Construction	2
Prototype Software Integration	2
Application Data Tracking	3
Machine Leaning Algorithm	2
Controlled Environment Harware Testing	2
Refine Prototype	2
Software Testing	1
Code Refactoring	1
Construct User Manual	1
Consumer Feedback	1
Finishing Touches	2

2.5 Project Tracking Procedures

What will your group use to track progress throughout the course of this and the next semester. This could include Git, Github, Trello, Slack or any other tools helpful in project management. You may wish to tie it in with your choice of development process in 3.6.

For this project, we will be using Git and Github to store our code and allow for multiple people to implement different features. It will also allow us to keep track of changes and to allow for multiple people to review code before finalizing updates.

We also plan on using Trello to keep people on task during our Agile sprints. This will allow us to assign cards and tasks to different people so that we can keep track of our goals for each spring. It will also allow us to monitor other people's progress so that we can know about any delays.

We will also use Discord as our means to meet as a team. This will allow us to meet electronically while allowing us to pin important conversations. It will also allow us to contact each other outside of our meetings and alert us when our team members are trying to relay important information.

2.6 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 the projected effort in total number of person-hours required to perform the task.

2.7 Other Resource Requirements

Identify the other resources aside from financial (such as parts and materials) required to complete the project.

Parts list

Android Studio

2.8 Financial Requirements

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

Budget is $500

Final product should have a cost less than $250

3 Design

3.1 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.

3.2 Design Thinking

Detail any design thinking driven design "define" aspects that shape your design. Enumerate some of the other design choices that came up in your design thinking "ideate" phase.

3.3 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?
- Some discussion of how this design satisfies the **functional and non-functional requirements** of the project.
- If any **standards** are relevant to your project (e.g. IEEE standards, NIST standards) discuss the applicability of those standards here

- This design description should be in **sufficient detail** that another team of engineers can look through it and implement it.

3.4 Technology Considerations

Highlight the strengths, weakness, and trade-offs made in technology available.

Discuss possible solutions and design alternatives

3.5 Design Analysis

– Did your proposed design from 3.3 work? Why or why not?

– What are your observations, thoughts, and ideas to modify or iterate over the design?

3.6 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.

3.7 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.

4 Testing

Testing is an **extremely** important component of most projects, whether it involves a circuit, a process, or software.

1. Define the needed types of tests (unit testing for modules, integrity testing for interfaces, user-study or acceptance testing for functional and non-functional requirements).
2. Define/identify the individual items/units and interfaces 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 have determined.

4.1 Unit Testing

– Discuss any hardware/software units being tested in isolation

4.2 Interface Testing

– Discuss how the composition of two or more units (interfaces) are to be tested. Enumerate all the relevant interfaces in your design.

4.3 Acceptance Testing

How will you demonstrate that the design requirements, both functional and non-functional are being met? How would you involve your client in the acceptance testing?

4.4 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 the design iteratively as you progress with your project
- If you are including figures, please include captions and cite it in the text

5 Implementation

Describe any (preliminary) implementation plan for the next semester for your proposed design in 3.3.

6 Closing Material

6.1 Conclusion

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

6.2 References

List technical references and related work / market survey references. Do professional citation style (ex. IEEE).

6.3 Appendices

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

If you have any large graphs, tables, or similar data that does not directly pertain to the problem but helps support it, include it 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.