IoT Elderly Care Solution

PROJECT PLAN

Dec19-18
Optical Solutions
Daji Qiao
Robert Guetzlaff - Hardware
Tyler Borchert - Hardware and Testing Engineer
Siyuan Zeng-Test
Nidhi Dalvi- Meeting facilitator and hardware
Jared Griffin - Web App Engineer/GitLab Administrator
sddec19-18@iastate.edu
http://sddec19-18.sd.ece.iastate.edu

Revised: 2019-02-17

Table of Contents

List of Figures

List of Tables

1 Introductory Material

1.1 Acknowledgement

Team 18 Client: Andrew Guillemette

Team 18 Advisor: Daji Qiao

1.2 Problem Statement

"The goal of this project is to make improvements and advancements of an previous capstone project". This project is intended for elderly individuals who wish to have their health monitored via sensors place around their place of residence.

Our group's specific goal is to fix the old solution, work on logic to detect when the resident missed a meal based on data stored on the server, create and install wireless sensor, implement a wireless solution that has a 1-2 battery life span, and display sensor events through a web app. "The objective of this project is to determine if the data collected from a series of sensors can help predict or see early signs of health deterioration".

1.3 Operating Environment

As the sensors will be placed at the apartment, so the end product will not cause any harm like extreme temperatures or other weather elements.

1.4 Intended Users and Intended Uses

There are two intended users for this project. First being the elderly individual who interacts with the system in the kitchen. They are the main users of this project. The second user is an individual who wishes to monitor the elderly individual's health.

The intended use of this project is to aid the elderly in monitoring their eating habits in the kitchen. Through the use of multiple sensors, we aim to predict whether the individual consumed food in accordance to their usual habits. This is then monitored by the individual who wishes to keep tabs on their elderly relatives.

2 Proposed Approach and Statement of Work

2.1 Objective of the Task

This project has four goals to accomplish. The first goal is to fix the current wired solution to produce meaningful data. Accomplishing this goal puts our project on the correct course. The second goal is to redesign the sensors as a wireless solution. This will make installation of the sensors easier in the testing environment. The third goal is to create algorithms to implement predictive logic to interpret the data collected by our hardware. This algorithm will be put on the cloud to predict if the consumer completed activities in the kitchen area. The logic will catch anything that seems to be out of the ordinary and report it to the end user. Lastly, we will create a WebApp that mirrors a previously created phone application. This will represent all the data collected and appear in a mobile web browser for easy access.

2.2 Functional Requirements

- Sensors don't produce correct data (Fix old solution)
    - Gain access to each Raspberry Pi & get the response and data collected by Pi.
    - Check if the data is reasonable. If not, we need to check if the sensors are installed properly. And debug the code.
- Detect when resident has missed a meal from data stored on the server (logic)
    - With the use of multiple sensor outputs, or lack thereof, to arrive at a reliable prediction.
    - Complete many test cases to ensure the logics reliability.
    - We need to recognize that the logic may not fit for everyone.
        - Machine learning. (Optional)
        - Data collecting and behavior record. (Optional)
- Create and install wireless sensor (wireless solution)
    - Research current wireless sensors and wireless transmission technology
    - Identify best solution based on:
        - Cost
        - Battery life
        - Data able to be recorded
        - Development time
    - Install new sensors
- Wireless solution must have a 1-2 year battery life span (wireless solution)
    - Ensure that wireless solution researched fits this requirement.
- Display sensor event status through a web app (web app)
    - Write a web application to pull and display data from the server.

2.3 Constraints Considerations

The constraints for our project are:

- Security requirements- Our project should limit access to sensitive information about individuals to those who need it. Be that a family member, member of staff, or a doctor.
- Cost- we will need to consider cost when moving forward in an attempt to make the most affordable end product in addition to the expense of hosting a cloud server with as minimal traffic as possible
- Ease of installation- Our project should be simple to install and add devices to so that someone who knows nothing about how it works can add monitoring to a home.

The non-functional requirements we discussed are the following things:

- App should be easy to use and navigate.
- Try to reuse the previous group's work.
- End door sensor solution should be wireless.
- Securely store data.
- Data gets analyzed in a timely manner.
- Non intrusive.
- Installed easily.
- System can handle an unexpected reboot.

These requirements are based on convenience, security, and efficiency. The users of our design are elders, so the design shouldn't be complex and difficult for elders to use. And since our project monitors the behavior of our users, we need to keep the data securely to guarantee their privacy and use the data in a good manner to avoid being intrusive. Also, since we have some works from the previous group, reuse these works can improve our working efficiency.

For the protocol standards, we basically follow three things: protect users' privacy, predict risky situations that may happen to our users and alert users to prevent risky situations to happen. Therefore, this project will not be unethical unless proper steps are not taken to ensure anonymity or that an individual's data isn't protected as that would violate the HIPAA.

2.4 PREVIOUS WORK AND LITERATURE

First, there was a previous group working on this project last semester, and the project web can be found at http://sddec18-14.sd.ece.iastate.edu/. They had made a prototype design for us to continue with. The previous group set up some sensors to record time interval between open & close a door(or drawer.), and the data can successfully send to Server and displayed on a mobile App.

The advantages of following this previous work are:

- Provide a prototype. So we can implement and design the project based on this prototype, which will reduce the amount of our work.

- Can evaluate the works they had done as a third one, which helps know the advantage and shortcoming of the previous design so we can have a clear direction to implement our project.

The shortcoming of following this previous work are:

- There are some parts not work properly in the previous work, so we have to redo these parts and fit the new parts into those working parts, which will be more difficult and time-consuming than design a new one.
- Some works are not kept properly so we can't find them. So there is some information we want but can't be found.

Second, we also found a similar design project exist. It is called: An IoT-aware AAL System for Elderly People. This project uses Raspberry Pi and gateway to monitoring the elders' indoor location. We can refer the communication between Raspberry Pi and server to implement our understanding, but since we are also monitoring the elders' behavior, this project doesn't contribute too much.
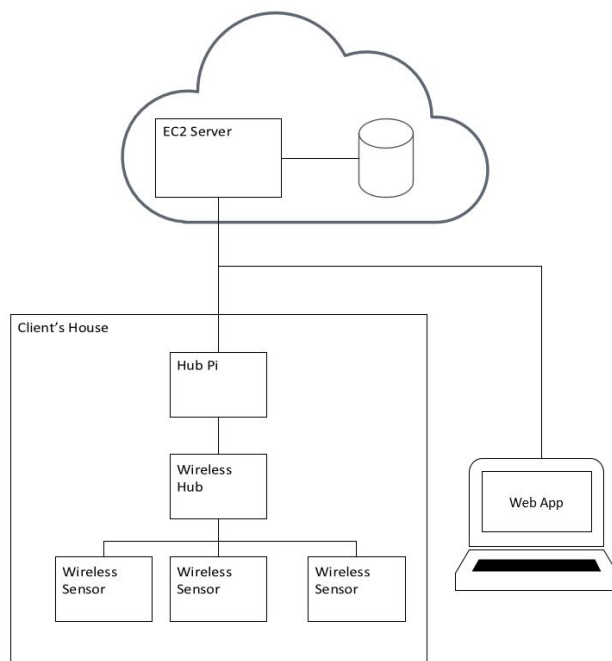
2.5 PROPOSED DESIGN

Figure 1: Block Diagram

We have three distinct design areas we will be working on, each of them will work together but be designed separately. The areas are, the sensors, the server logic, and the web app.

The sensors are physical door sensors that are placed throughout the test environment the controller that they are connected to. This controller relays back to the cloud any event data. Ten wired sensors with two controllers and one hub are currently deployed at the test environment by the previous group, however their implementation currently throws incorrect data. The final goal for the sensors is to have them be wireless and only sending correct data. To this end find a wireless alternative to these sensors that will be more reliable and have a minimal impact on the test environments aesthetics. Alternatively we will find the error with the current wired sensors and fix it.

The server will receive and analyse the data from the sensors to determine if the test person has completed daily tasks. Our first goal is to determine if our tester has missed a meal and if so, flag and report this data. This system will be run from an Amazon Web Services (AWS) account in the cloud and will integrate with our web app and SdMay19-36's Android application. The current alternative for this aspect is to have an onsite computer process the data to eliminate the risk of loss of internet.

The web application will provide a way for the tester to view sensor data as well and the analysis of the events. This interface will start out as our debug interface for the server logic.

2.6 TECHNOLOGY CONSIDERATIONS

The current setup we inherited from SdDec18-14 uses magnetic sensors wired back to two Raspberry Pi Zeros, which, in turn, communicate back to a single Raspberry Pi 3 for the sensors, and an AWS EC2 instance for the database and the server. Upon taking over this project the Pi's had stopped communicating with the server. The loss of communication seems to lineup with a reported power outage. This is our first consideration, the Raspberry Pi's run a version of linux called Raspbian. While this is a stable and well known operating system at this time, an operating system adds additional areas for fault. In this case since the devices were power cycled the program to record sensor data was not restarted. Physical access to the test environment may be required to fix specific faults.

The AWS server we are using for our data storage and processing is free for our purposes but requires an internet connection to receive data from the test environment. should internet go out, at best data transmission would be delayed. 4/5G failover and onsite data processing are current ways to overcome this problem. 4/5G failover would use the cellular network to transmit the data, with the drawbacks that cellular data is more expensive than traditional internet and the possibility that both systems could fail at the same time. Onsite processing of the data could be used to analyse events but requires a

computer to be in every test environment, which violates our need to be as unobtrusive as possible. A combination of both of these methods could be used where we process the data if a connection cannot be made to the server, then only transmit over 4/5G if an event has been missed.

2.7 SAFETY CONSIDERATIONS

Nothing we are working with is inherently dangerous. Our logic triggering a false positive would only result in an extra check up on the tester. The only source of danger is our logic detecting a false negative and not creating an alert for a missed meal. As this is a prototype system, it should not be being relied on as the primary source of health information for our tester while we are developing it.

2.8 TASK APPROACH

Our planned approach is first get the sensors working to the point where they stop giving us incorrect data. Then, with the sensor data, we will start building our logic system using the testers known activities coordinated with the data. Once we have our base logic we will test it against the data and improve the detection. Finally we will implement our web app to show the user the data recorded by the sensors and the events detected by the logic.

2.9 POSSIBLE RISKS AND RISK MANAGEMENT

The largest risk to the development of our project is that all of our hardware is offsite. Our sensors and sensor controllers are at our test environment, which is a person's apartment, and our server code will run on a cloud server. Should something happen to our sensors or their controllers we have to coordinate with our tester to get physical access to them. Similarly, should AWS go offline we will lose access to our server and our data. This is a much smaller risk in our opinion, but it is something to be aware of.

2.10 PROJECT PROPOSED MILESTONES AND EVALUATION CRITERIA

Hardware Milestones:

- The current sensors in place give off good data to the cloud to start logic.
    - Data is within reason, as in no impossible values.
    - Will be tested by numerous test cases
- Update the current solution that allows the production of good data
    - Physically push code to each of the Raspberry Pis in the testing environment.
- Researched various type of wireless solutions and compile a list to present to client.
    - Have enough information in order to accurately describe each proposed sensor.
- Implemented the wireless sensor into a prototype for testing.

- ○ Implement the wireless sensors into given prototype to begin testing its functionality.
- Install the new wireless sensors into the testing environment.
  - ○ Physically replace and install new wireless sensors into testing environment.

Logic Milestones:

- Able to interpret the given data by hand.
  - ○ Able to understand the data to predict by hand that the individual is eating or not eating.
- Plan and design for the logic algorithms.
  - ○ Test and compare results with Bob's confirmed results.
- Verify and deploy the logic onto the server.

Web Application Milestones:

- Maintain feature parity with the Android application being built by another Senior Design group working with the same client
  - ○ Compare application with other group to ensure functionality stays the same.
- Integrate and display the data generated by the behavior logic system
- Create a testing suite for unit, acceptance, and integration testing the web application
- Develop a continuous integration pipeline to deploy the web application on Amazon Web Services (AWS)

2.11 PROJECT TRACKING PROCEDURES

Our group's progress will be tracked by our weekly reports and meetings. Our weekly reports will always mention what the group accomplished each week. While in each meeting we will discuss where we are in our project. This will help us keep on track for the entire semester. It is always helpful to know where we are as a group each week with these meetings.

2.12 EXPECTED RESULTS AND VALIDATION

The desired outcome is to have functional testing environment where we can collect data on an individual and observe whether there are derivations in their usual daily habits. This involves having a functional sensor, proper logic, and a web application to view allocated data. The user will be able to view all this data that is collected on said web application. At a high level a user will be able to view the data that has been collected by the sensors. Also, they will be notified if usual daily habits have changed. If the user can complete these tasks, then we know that we have accomplished our goal.

2.13 TEST PLAN

Hardware Testing:

Wired Sensors

These sensors will go through tests conducted by the engineer. This will be done by using the prototype given to us by the client. Here we can run the code and test it physically. The success is determined by the data that is collected and sent off to the cloud. Some of these tests will need to be run over the course of a week or longer. This is because these sensors will be on 24/7. Seeing if there are edge cases over long periods of time are essential.

Wireless Sensors

These sensors will also be tested on the protype. Since the wired solution is already present, we can directly compare the data that it is producing. It will go through the same tests as the wired solution. Directly comparing one solution to the old is the best way to tell of its success.

Logic Testing:

Code itself

The code will be tested will a provided data set. We were given a data set with an individual's habits over the course of a couple of weeks by the client. Here we can input the data to drive the code to make predictions. The code can be determined as a success if we can predict when the individual ate at the correct times as determined by the set of data.

Testing in designated Environment

The code will need to be tested with all the sensors in the environment it is designed for. Here we will have the data created over X amount of time and have the individual write down the times they ate. Then we compare the results after the testing period and evaluate the results.

Web Application Testing

Reliability Testing

Need to test to make sure that the application works in different cases. This can be set up by using the web application on different phones and different browsers.

Information Testing

The web application will be tested by opening it up to information. This is where we can see if data is getting represented correctly.

3 Project Timeline, Estimated Resources, and Challenges
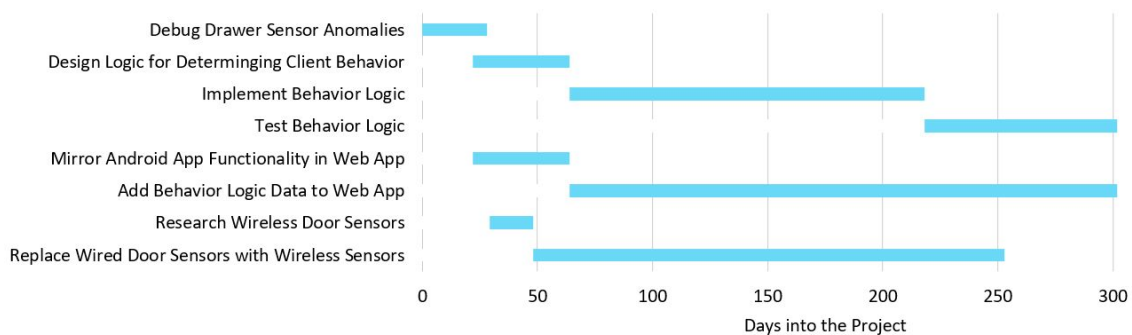
3.1 PROJECT TIMELINE

Figure 2: Project Gantt Chart

There are three major deliverables for this project: integrating a set of door sensors into the work a previous Senior Design group completed, designing an algorithm to take the data generated from the door sensors and predict the health of the elderly resident using the system, and creating a web based application to display pertinent information. There have been some goals outlined for our group. Firstly, we need to devote the majority of our energy initially to resolving data anomalies from the system a prior Senior Design group created. Due to this, we have set this objective as the first one to complete. As we are wrapping up this task, our client has specified to begin working on the three other deliverables in parallel. There are some interdependencies between the three deliverables, so some of the tasks are staggered with this taken into account.

In order to finish the project on time, we have built in a large amount of time around each task. This will allow us to break the tasks up into smaller sub tasks as we learn more about what each task will entail. Please note that the Gantt chart above does include time over the summer. We will not be working on the project during this time, but we have elected to include that time to better express the time the project will take.

3.2 FEASIBILITY ASSESSMENT

We project that we will be reimplementing work once completed by a previous Senior Design group as well as implementing a web based application for accessing data related

to the logic we develop for sensing events related to the resident testing our project. Some of the challenges we will face are shifting requirements from our client since our client is a start up company and they may have to shift their goals unexpectedly. We also are trying to build upon the work executed by a previous Senior Design group. As such, there will be challenges related to becoming familiar with what that group completed and making improvements to their work.

3.3 PERSONNEL EFFORT REQUIREMENTS

Task	Description	Time Estimate
Debug Drawer Sensor Sensors Anomalies	Determine what is causing a data anomaly in the previous Senior Design group's work and resolve the issue.	~ 20 hours
Design Logic for Determining Client Behavior	Create a set of relationships between how the elderly resident interacts with our sensors and signs that the individual's health is declining.	~ 40 hours
Implement Behavior Logic	Take the relationships previously outlined for determining the health of the elderly resident and implement them on a server that can process the sensor data being recorded in the elderly resident's apartment.	~ 80 hours
Test Behavior Logic	Create an acceptance testing suite to simulate the elderly resident's behavior in order to test that the logic system recognizes the correct behavior patterns.	~ 40 hours
Mirror Android App Functionality in Web App	Take the functionality in a pre-existing Android application and reimplement it inside of a new web application.	~ 40 hours
Add Behavior Logic Data to Web App	Integrate the data generated by the behavior logic server into the web application.	~ 60 hours
Research Wireless Door Sensors	Research wireless door sensors technologies and how we could go about integrating this into our current system	~ 40 hours

Replace Wired Door Sensors with Wireless	Reimplement the door sensing system using the wireless sensors previously researched	~ 100 hours

Table 1: Estimated time Requirement.

3.4 RESOURCE REQUIREMENTS

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

Resource	Cost
Raspberry Pi 3	$0.00*
Raspberry Pi Zero	$0.00*
Wireless Door Sensors	**
AWS EC2 Server	$0.0208/hr
AWS RDS Database	$0.017/hr
AWS S3 Storage Bucket	$0.0237/GB
Onsite Server Computer	$0.00*

Table 2: Estimated Resource Requirements

* The cost is zero because these products are already owned by the client

** The cost for the wireless sensors will not be known until research is complete in that subject

4 Closure Materials

4.1 CONCLUSION

For elders who live alone, careful attention needs to be paid to guarantee their safety and health. However, get a live-in nurse, or move to a nursing home to live out the rest of their days is expensive and inconvenient. Out project provides a new solution by using a series of sensors inside the home to remote monitoring the activities happened within the home and notice the elders' doctor/family member if there are potential risks that may happen.

Our solution will consist of sensors sending data to a local server. This server will perform any formatting or interpretation of the data, and data will be well analyzed to determine if good behaviors are taken by the users, or to determine if there are irregular behaviors happened.(For example, the user didn't wake up at the normal time or the user didn't eat lunch/ breakfast.) And then the server will send the results to the mobile App. The Mobile App will display the results textually or graphically and notify the user's doctor/family member.

Our team members have great understanding and experience in embedded system and programming so we have confidence for this project.

4.2 REFERENCES

AWS EC2 Pricing: https://aws.amazon.com/ec2/pricing/on-demand/

AWS RDS Pricing: https://aws.amazon.com/rds/mysql/pricing/

AWS S3 Pricing: https://aws.amazon.com/s3/pricing/

http://seniord.ece.iastate.edu/approved-projects-sddec19.pdf