Department of Computer Science & Engineering
The University of Texas at Arlington

Project Charter
CSE 4316: Senior Design I
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The Brews
Bluetooth Hydrometer

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Revision History

Revision	Date	Author(s)	Description
0.1	2.27.2021	JAG,DPKH,JA,CRM	Document creation
0.2	5.1.2021	JAG	Version 2
0.3	8.3.2021	JAG	Final draft with updated logo and changes to project poster section

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1 Problem Statement

Most homebrewers cannot afford expensive fermentation equipment. An important part of the brewing process is to be able to measure the specific gravity of the beer. Homebrewers will more than likely have to open up their fermenters in order to obtain measurement samples. The device we plan on making would send the specific gravity measurement to your phone or a web server. We want to remove any opportunity for possible contamination by keeping the keg closed during the fermentation process. This will save brew since samples will no longer be needed to be taken from the keg to be tested on a hydrometer outside of the keg.

2 Methodology

We plan on making a tilt hydrometer by combining a microcontroller with a temperature sensor and inertial measurement unit (IMU). It would also have a Bluetooth module, allowing us to send the data to your phone running an app or to a web server on a Raspberry Pi. Using this, the user could monitor fermentation, and if they have remote control of their fermentation system, change the temperature.

3 Value Proposition

Most homebrewers can't afford an expensive conical fermenter. They brew either in big glass fermenters or plastic food-grade buckets. In order to get a sample, they bust open the fermenter, exposing the beer to potential contamination. It would be nice to be able to measure the specific gravity with a device that can be sanitized and placed in the fermentation vessel at the end of the brew day as you fill it. This is where the development of our tilt hydrometer would help.

4 Development Milestones

List of milestones and completion dates for our Tilt Hydrometer project:

- Project Charter first draft - March 1, 2021
- System Requirements Specification - March 22, 2021
- Architectural Design Specification - April 12, 2021
- Demonstration of Working IMU - June 2021
- Detailed Design Specification - July 2021
- Demonstration of Bluetooth Access for data - July 2021
- Demonstration of Data Logging to Phone App or Web Server - July 2021
- CoE Innovation Day Poster Presentation - August 2021
- Demonstration of Specific Gravity Readings- August 2021
- Final Project Demonstration - August 2021

5 Background

Homebrewing can be viewed as both a fun and potentially money saving hobby. The problem is that most home brewers cannot afford expensive fermentation equipment. Even a few of the basic equipment essentials such as wort chillers can cost upwards of 200 dollars [5]. If you ask most homebrewers they probably won't tell you they are in it for the money, but rather the personal experience and gain they get out of it. Crafting cheap beer allows you to save some money. Crafting something you can call your own and sharing it with your friends and family is priceless. Any method that would either make the yield of the beer you get from home brewing greater or save money on equipment would service to make the home brewing experience better. That is what our team plans to accomplish. Our sponsor Dr. Conly is a home brewer himself. He wants our team to develop a tilt hydrometer to use for measuring the specific gravity of the beer. Measuring the specific gravity of the beer tells you how much sugar is dissolved in the liquid. Since, the sugar is consumed by the yeast to produce alcohol and CO2, knowing the specific gravity allows us to both estimate the alcohol by volume(ABV) of the beer and know when fermentation is finished [9]. Most home brewers end up having to take a sample of their brew in order to measure the specific gravity. This can be upsetting especially if you are taking one sample per day, because that is more and more beer lost. You can not put it back in the fermenter, as that can potentially introduce contamination and you may lose the entire batch. There are many types of bacteria that are known to contaminate homebrew which include lactic acid bacteria, acetic acid bacteria, pectinatus, megashaera, and Zymomonas [3]. This is not a problem for professional brewers that can afford expensive conical fermenters since they can take a sample without opening the fermenter. Some of the most basic conical fermenters cost around half a thousand dollars [4]. As young adults ourselves who also enjoy beer and the possibility of home brewing in the futurei, we can see the value customers see in being able to sample their brew during fermentation without reducing any yield or possibly introducing contaminants during the process.

6 Related Work

Today, beer brewing and wine making are huge, enormously profitable agricultural industries.These industries are the result of the laborious work of hundreds of scientists who were curious about how things work. Everything from how glycolysis works to the type of yeast strain used needs to be kept in mind when brewing beer [1]. There are a few traditional ways of measuring the specific gravity during the brew process. Professional breweries use expensive digital devices. Digital hydrometers typically use a W-shaped oscillator made of a borosilicate glass. They have a long filling tube to reach into tanks and containers [8]. Those are out of reach for most home brewers. Some people use an analog hydrometer. It is simply a glass tube with a weight in the bottom and graduated markings along its stem indicating specific gravity [7]. The denser the liquid (i.e. higher specific gravity), the less it sinks. The thinner the liquid (i.e. lower specific gravity), the deeper it sinks in the liquid. It takes a fairly large sample of liquid to float the hydrometer. Other brewers use a refractometer, which involves putting a few drops on a crystal. The light refracts and "draws a line" on a scale indicating specific gravity when you look through the eyepiece [2]. The problem with refractometers is that once alcohol is present in the liquid, it throws off the readings, as alcohol refracts light differently than water [6]. They are great for finding the starting gravity, or specific gravity before fermentation has begun. They also require calibration with distilled water at a specific temperature. Analog hydrometers are calibrated at the factory. All three methods are commercially available but they involve taking a sample of varying size. For professional brewers (and homebrewers that can afford expensive conical fermenters), this isn't a problem, since they can take a sample without opening the fermenter. Homebrewers will often be upset about losing the sample, especially if you're taking one every day. Our tilt hydrometer will measure the specific gravity with a device that can be sanitized and placed in the fermentation vessel at the end of the brew day as you fill it. The device would send the gravity to your phone or a web server.

7 System Overview

We plan to implement en electronic hydrometer, Bluetooth capabilities, and an API/web app to limit interaction with the fermentation process. This will allow for a cleaner and simpler experience when wanting specific gravity or temperature data from the brew. The electronic hydrometer will have hardware that will be able to analyze the angle it is floating at to measure the specific gravity of the liquid and temperature. Since we are not measuring the temperature and specific gravity by taking samples, we need this hardware to sense and record the data for us. This is an imperative aspect of our project since our main goal is for the hydrometer to communicate data that will allow the user to observe the progress of their fermentation process. Another advantage our electronic hardware will have over conventional hydrometers is the inherent sensitivity of electronics. The data gathered by the hydrometer will be more accurate compared to a human measuring and recording these measurements. This electronic functionality we are implementing allows the hydrometer to gather data with out human intervention and with more accuracy. To interact with the hydrometer, request data, or send commands, we need to build Bluetooth capabilities for our device. The electronic hydrometer is able to read data, but that does not solve our problem if we still need to open the keg to posses this data. Implementing Bluetooth allows for more precise and accurate monitoring of temperature and specific gravity since it will be in the keg until the user is satisfied with their brew. This functionality also removes the need to expose the fermentation process and will reduce the waste brew. We will need to build an API/web app to define how we want the user to interact with our device. We want the user to have a flexible experience when they read data and adjust the temperature of their brew. It will be implemented with the intention that the user will want to check the specific gravity and temperature of their brew with their phone. This allows for flexibility that a non Bluetooth hydrometer lacks, since the user will be able to check on their brew when ever they are connected to WiFi, despite being away from their home-brew set up. With out the web app, there will be no way to communicate with the hydrometer, regardless of its electronic components and Bluetooth capability.

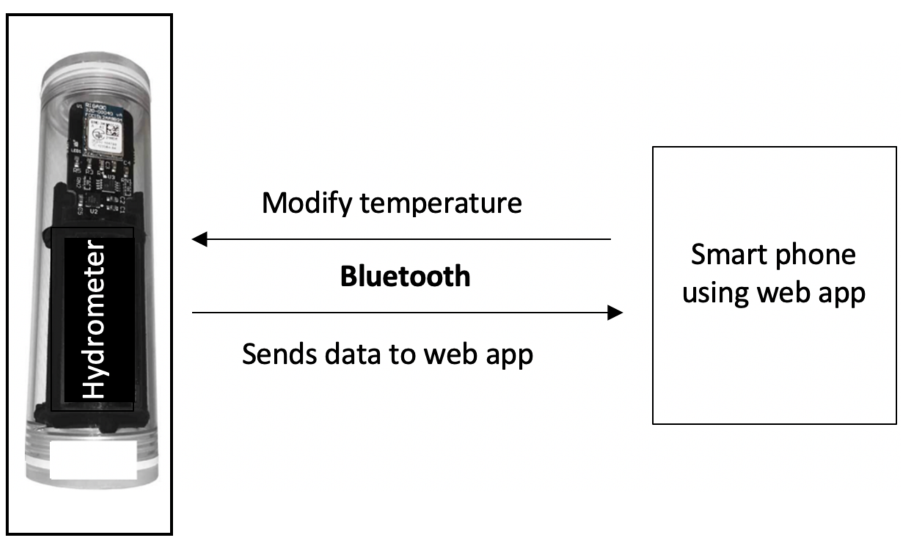

Figure 1: Tilt Hydrometer Diagram

8 Roles & Responsibilities

The stakeholders for our project include Dr. Conly and Dr. Gieser. Christopher Conly is a senior lecturer and undergraduate advisor in the department of computer science and engineering at The University of Texas at Arlington. Shawn Norman Gieser is an instructor in the computer science and engineering department at The University of Texas at Arlington. Dr. Conly will be serving as our team's sponsor and our point of contact for the majority of our project inquiries. Our team is composed of Doungpakanh Paige Keomaxay-Hampf, Jesus Adrian Guerra, Calvin Mata, and Jorge Avila. Jesus Adrian Guerra is an undergraduate computer engineer with a bachelor of science in biology from The University of Texas at Arlington. The team has decided that because of his age and experience with public speaking due to his role as V.P. and President of UTA's pre pharmacy association in 2013, that he would assume the role of product owner. Calvin Mata has had prior experience with scrum and so the team has decided he will be the scrum master. Both scrum master and product owner roles will be subject to rotation if either role becomes too exhaustive. Jesus, Jorge, and Paige are undergraduate computer engineers while Calvin is an undergraduate in computer science. As a result most of the hardware from this project will be accomplished by Paige, Jesus, and Jorge. The hardware will include the temperature sensor, inertial measurement unit, battery system, and work with selected microcontroller. Any custom circuit boards created will the responsibility of Jorge and Jesus since they have the most experience with soldering and circuit board development. Calvin will be in charge of most the software requirements including the creation of a web app to allow for the remote monitoring of temperature and specific gravity.

9 Cost Proposal

The approximate budget will be 800 dollars which will be provided to our team by the CSE department here at The University of Texas at Arlington. This budget will mostly cover the hardware expenses for things such as the microcontroller, circuit boards, Raspberry PI, and hardware required for the development of the temperature sensor and battery system. No software licenses are needed at the moment.

9.1 Preliminary Budget

Project Item	Estimated Cost
Microcontroller(i.e. Arduino Nano)	40 dollars
Rasberry Pi	80 dollars
Circuit boards	20 dollars
Jumper wires	10 dollars
IMU or AHRS(Attitude Heading Reference System)	150 dollars
Plastic enclosure	10 dollars
Breadboards	10 dollars

Table 1: Component Budget

9.2 Current & Pending Support

Our team will be receiving 800 dollars of funding from the CSE department at UTA. Dr. Conly has informed our team that he would provide us with more budget if any is needed.

10 Facilities & Equipment

In order for our team to complete the tilt hydrometer project we will need access to several different locations both on and off campus. We will be using the senior design lab as well as the CSE electrical engineering maker space. In the maker space and Senior Design lab there is a power supply, signal generator, digital multi-meter, and an oscilloscope to test our soldered hardware. We will use the senior design lab for any work with circuit boards and soldering we plan to do. The CSE electrical engineering maker space will give our team access to 3D printers(Polyprinter 229's) that we may use for help designing hydrometer parts, milling machines that can make single and double sided PCB's straight from Eagle software, and Dell workstations in case our team decides to use Autocad or Matlab for anything. UT Arlington's central library has access to a Fabrication Lab. The Fab Lab is an 8000 square foot space containing 3D printers, laser cutters, screen printers, and kilns in case we need to use any of this equipment. We will also have access to Dr. Conly's home for testing our project. Dr. Conly home brews often and has kegs and fermentation equipment that we will need for testing the effectiveness of our tilt hydrometer. Outside of campus our teammate Jesus Adrian Guerra has allowed us the use of his back house in case we need to meet in person as a group to work on project milestones. Jesus has access to soldering equipment for use outside of campus. We will also need to meet off campus at times to put our project parts together so we will be using Jesus' back house for that when necessary. Jorge also has soldering equipment so when Jesus' house is not available Jorge's house will be our secondary option for any off campus meetings.

11 ASSUMPTIONS

The following list contains critical assumptions related to the implementation and testing of the project.

- A suitable testing location will be available at Professor Conly's house with his home-brew set up
- The hardware components will accurately measure specific gravity and temperature
- Professor Conly will be a reliable source for consulting
- Bluetooth will be able to connect to devices outside of the keg
- Team proficiency in soldering

12 CONSTRAINTS

This section should contain a list of at least 5 of the most critical constraints related to your project. For example:

The following list contains key constraints related to the implementation and testing of the project.

- Final prototype demonstration must be completed by August 2021
- We will not be able to test with actual brew until after the Spring 2021 semester
- Due to Covid-19, we are having to work remotely for majority of the project
- Total development costs must not exceed $800
- We will have to wait for hardware to be shipped to us after ordering parts

13 RISKS

The following high-level risk census contains identified project risks with the highest exposure. Mitigation strategies will be discussed in future planning sessions.

Risk description	Probability	Loss (days)	Exposure (days)
Possible infection of Covid-19 of team member	0.05	14	.7
Testing grounds at Professor Conly's house are not available	0.20	20	4.0
Internet access not available at testing site	0.10	10	1
Delays in shipping for hardware	0.30	14	4.2
Accidentally breaking hardware and plastic enclosure	0.15	14	2.1

Table 2: Overview of highest exposure project risks

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

The initial document file will be submitted by Jesus Adrian Guerra on March 1st, 2021 via canvas. Each team member will have a copy to maintain. We will discuss once per week on Sunday whether or not any project changes dictate changes the project charter. The final version will be delivered on May 4th, 2021 by Jesus Adrian Guerra via canvas.

14.1.2 System Requirements Specification

The initial document file will be submitted by Jesus Adrian Guerra on March 22nd, 2021 via canvas. Each team member will have a copy to maintain. We will discuss once per week on Sunday whether or not any project changes dictate changes the SRS. The final version will be delivered on May 4th,2021 by Jesus Adrian Guerra via canvas.

14.1.3 Architectural Design Specification

The initial document file will be submitted by Jesus Adrian Guerra on April 12th, 2021 via canvas. Each team member will have a copy to maintain. We will discuss once per week on Saturday whether or not any project changes dictate changes the ADS. The final version will be delivered on May 4th, 2021 by Jesus Adrian Guerra via canvas.

14.1.4 Detailed Design Specification

The detailed design specification document will be maintained on overleaf so that the entire team can update it as needed individually. It will be updated anytime design specifications get updated or changed. The initial version will be submitted in June of 2021 and the final version in July of 2021.

14.2 Recurring Sprint Items

14.2.1 Product Backlog

Once initial work on the SRS begins we will discuss as a team what items if any need to be placed into our product backlog. These items will be prioritized by time needed for completion. As a group we will vote on what items will have priority and which need to be added to the product backlog. JIRA software will be used to maintain and share the product backlog with team members and stakeholders.

14.2.2 Sprint Planning

After each Sprint is finished we will discuss as a group what items we need to work on next in order to progress towards completing our project. We will use that information to create our following Sprints. We will have a total of 7 sprints throughout both senior design 1 and 2.

14.2.3 Sprint Goal

We decide our sprint goal as a group with votes. Dr. Conly is also known for home brewing so we can involve our customer in this process by asking him what he advises us to work on next.

14.2.4 Sprint Backlog

The team decides by voting which items make their way into the sprint backlog. The backlog will be maintained via Jira leveraging scrum with Calvin Mata being our scrum master.

14.2.5 Task Breakdown

Individual tasks will be assigned from the sprint backlog by having each team member voluntarily claim a task. Time spent on tasks will be documented by the individual who performed the task and inserted into actual time for the next sprint.

14.2.6 Sprint Burn Down Charts

Calvin Mata as the SCRUM Master will be in charge of the burn down charts. Generating and explaining our work throughout the sprint. Team members will post their hours worked on Microsoft Teams to the SCRUM Master for him to keep track of. Microsoft Word will be used to create and format these charts using our sprints.

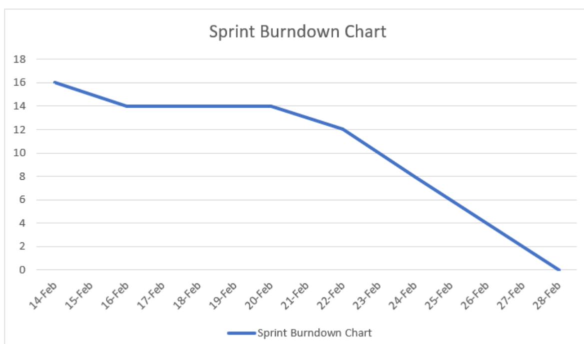

Figure 2: Example sprint burn down chart

14.2.7 Sprint Retrospective

Sprint Retrospective is due two days after the sprint review. It will happen right after class when we submit our sprint review and we will handle the discussion as a group. We will document what we did well as a team/individually, what we did badly as a team/individually, improvements that we could work on, and praises for team members.

14.2.8 Individual Status Reports

Individual Status Reports will be reported by each individual team member discussing our sprint's progress, such as the following: task progress, spikes, budget summary (hours and currency).

14.2.9 Engineering Notebooks

Our Engineering Notebooks will be updated concurrently as we are working on our sprints. This will create a chronological timeline of progress. The minimum that we will complete will be one page during each sprint. This will be done individually by each team member. The team will meet the day before the sprint is due to keep each other accountable. We as individuals will be accountable and sign/date each ENB.

14.3 Closeout Materials

14.3.1 System Prototype

The final system prototype will include a microcontroller with temperature sensor and inertial measurement unit. It will also include a Bluetooth module for data transfer. This will be demonstrated using the tilt hydrometer we design for containing all our hardware, that will ideally be placed into a brew container to measure specific gravity. The date of this demonstration should be sometime in August 2021. We will not have a Prototype Acceptance Test and nothing as of now is set to be demonstrated off-site.

14.3.2 Project Poster

The project poster will contain a high overview of the Bluetooth Hydrometer. It will have an executive summary, background for the need of our device, constraints, ADS diagram, picture of our prototype and testing, lessons learned, future plans for any unfinished work, and references. This will be a 40"x 32" poster to be delivered as a template for printing on demo day.

14.3.3 Web Page

Our web page will be created on the Senior Design Student Project Repository. It will contain information such as our project's background, requirements, system overview, results, project files, and future work. This will be a public domain, so that other users may look at our project ideas. This website will be provided at the end (closeout).

14.3.4 Demo Video

Videos will be recorded throughout the time of the team working on the product so that we can create a detailed demonstration on demo day. Topics will include: building hardware/software, content overview and designs. This video will be roughly 10 to 15 minutes long and no B-Reel will be included.

14.3.5 Source Code

We will be using GitHub to maintain our source code leveraging git version control (no binaries). The stakeholder will have access to our source code to view and accept any changes throughout the sprint. This code will not be licensed, but only the internal team can access the GitHub (which indicates private code), which allows the stakeholder to clone the code for their use.

14.3.6 Source Code Documentation

We will use Doxygen to extract and use as a document generator. When used for analysis this file will be formatted into a PDF. Standards include: proper indentations comments, citations of external sources, proper git commit messages.

14.3.7 Hardware Schematics

We will use PCB boards for prototypes. Our team will solder and wire components to their prospective schematic which we will create further down the project life cycle. Schematic software includes EasyEDA and EveryCircuit. We may also leverage tools such as etch located in the senior design rooms to better create laser cut circuitry.

14.3.8 CAD files

We will possibly use TinkerCAD for additional components such as: casing, logos and other non priority components. Upon creation these files will be formatted as OBJ for our closeout materials.

14.3.9 Installation Scripts

We will provide a READme file on downloading external scripts such as node and shell scripts. No team defined scripts will be created at this time for our project.

14.3.10 User Manual

We will have a printed manual that will inform the user on how the Bluetooth Hydrometer functions, as well as guide for accessing the application on their phone or web server on a raspberry-pi, to access the Bluetooth module data.

REFERENCES

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