S.P.I.C.E.

Project Proposal

Salty Seniors

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Table of Contents

1 Executive summary

In the United States, approximately 27% of adults over 60 live alone. This is a distinct contrast to other countries which average 16% of adults over 60 living alone. [1] For various social, cultural, and economic reasons, older generations in the United States tend to be more independent than other countries. As the average age in the United States continues to rise, it will become increasingly necessary to provide accessibility and convenience tools for adults whose motor functions decline with age. The goal of the S.P.I.C.E. project is to develop a tool that will make cooking more accessible by simplifying the spice measurement process. The S.P.I.C.E. project can be broken down into three major objectives. Accessibility, Convenience, and Easy Maintenance:

- **Accessibility:** With the target audience of S.P.I.C.E. encompassing older adults, it's important that the product be accessible to this group. While motor dysfunction is one of the most common difficulties for older adults, there are others to consider. For example, larger buttons and text on a user interface may help users identify the different S.P.I.C.E. functionalities. A touch screen connected to the device may make interaction easier than a connected mobile application. The goal of these accessibility features is to make the end user's experience as helpful and intuitive as possible.
- **Convenience:** S.P.I.C.E. should be convenient to use for everyone, especially for older adults. This means that S.P.I.C.E. will be designed in a way such that there will be no need for an overly convoluted manual. The set-up process will be straightforward and the user interface should guide users directly to the action they intend to take. It should also be convenient for users to add and remove spices, as well as input what spices are in the housings. This approach will dictate how certain User Interface (UI) elements are designed, as well as how S.P.I.C.E. will track what is available to the user.
- **Easy Maintenance:** It would not make sense for an accessibility product to require complicated maintenance. For this reason, components will be made to be easily detachable and washable. This will give users the ability to seamlessly swap spices as well as maintain the S.P.I.C.E. housings. Additionally, S.P.I.C.E. will be made robust enough to prevent damage to the microprocessor and microcontroller, giving the device an extended lifespan in a kitchen environment.

The literature review **(Section 3)** revealed a number of different approaches to assisted cooking. Each approach had its own benefits and issues, but none actively engaged with a spice dispenser as an accessibility tool. All the previous products and projects took a more commodity approach, and as a result, are lacking key features that would fulfill the S.P.I.C.E. objectives. For example, some of the other dispensers utilize an external interface (e.g. mobile app/computer interface) while S.P.I.C.E. intends to use a more holistic integrated interface. Many of the mechanical components in S.P.I.C.E. will be similar to the products found in the literature review. However, they will have to be slightly adjusted to match constraints and hardware implementations.

As for hardware, S.P.I.C.E. will utilize both a Raspberry Pi and Arduino board to control various servos and motors. The implementation of an interface on the Raspberry Pi will be separate from motor control on the Arduino. Since the Raspberry Pi has a pre-integrated operating system, it will have the flexibility of working with most programming languages. This way, the user interface can be implemented in a flexible manner. Networking between the Raspberry Pi and Arduino may be a challenge, however, it will be a less costly challenge than attempting to put all motor control onto the Pi itself.

S.P.I.C.E. is expected to make cooking more convenient for older adults. This is a worthwhile benefit, as home cooked meals tend to be more healthy than take-out ones. Not only will this keep users of S.P.I.C.E. healthier, it will also help older adults feel more comfortable being independent at home.

2 Introduction

2.1 Problem Background

In the United States, it is estimated that close to 27% of adults older than sixty live by themselves. This is in stark contrast to foreign countries which average about 16%. Based on economic and cultural factors, older adults in the United States are significantly more likely to live by themselves or with one other person (usually a spouse of approximately the same age). [1] Based on a 2022 study conducted by Dr. Laurence Knott, age accounts for approximately 1-2% loss in functional ability per year [2]. This comes as a result of changing body composition, reduction in bone mass and blood volume, and other physiological changes. Due to frailty with age, problems can begin to arise as these adults begin to gradually lose motor control.

There are also adults under sixty but still struggle with motor function disabilities. Approximately 39 million Americans in all age groups suffer from some kind of motor impairment disability. [3] These two groups may find it difficult to complete tasks requiring precise movements. One of the most important of those tasks being cooking, which can require various kinds of precise motor control. It's easy to take for granted the ease of measuring out something small like a tablespoon or teaspoon. However, not everyone can easily make these smaller measurements, especially as they age. The scope of the S.P.I.C.E. project encompasses spice measurement and mixing, both as an accessibility and convenience tool.

2.2 Needs statement

Fine motor control can decline with age, but also comes as a result of various disabilities. [3] In a country where one in four adults have some form of motor impairment and older adults are more likely to live alone, there's a serious need for tools that can make tasks easier for motor impaired adults. [1] In order to meet this need, S.P.I.C.E. aims to make cooking easier and more convenient for households where measuring spices for recipes may be an issue.

2.3 Goal and objectives

The goal of this project is to reduce the strain and inconvenience of precisely measuring quantities of spices for people with motor disabilities when cooking.

The following is a list of objectives that will be taken into consideration throughout the S.P.I.C.E. design process:

- Accessibility
  - The system should include an interface that is easy to use.
  - The system UI should be intuitive and naturally guide users to operations they want.
  - The distribution of spices must be accurate to $\pm$ 0.1 teaspoon.
  - The system should be capable of dispensing a minimum measurement of 1 teaspoon
- Convenience
  - The system must support at least four different spices with different spice mixes.
  - The overall design must have a reasonable level of water resistance.
  - The system must be able to properly function in the temperature range 65-75°F(18-23°C).
  - The system must fit in a 45x45x45cm box.
- Easy Maintenance
  - The system must be easy to disassemble and maintain.
  - Cleaning spice housings must be easy and intuitive.
  - Spice dispensers must remain unclogged even after prolonged use.

2.4 Design constraints and feasibility

The most significant constraint of the project is the budget. This project aims to be an affordable accessibility solution for people with declining motor function. Currently, there are no similar solutions available for purchase, so there are no commercial competitors and products available for a price reference. However, the available $200 budget will be used as a guideline to keep the project at a reasonable price for the first of its kind officially on market.

From an ergonomic perspective, the system will need to exist and operate comfortably in a kitchen environment. As with most of the previously mentioned solutions, this system will need to function at an average room temperature of 65-75°F (18-23°C), withstand some moisture levels, and fit within a reasonably chosen size constraint measuring 45x45x45cm.

Lastly, there are a few quality of life constraints that will influence this project. To be successful, this product will need to accurately dispense a minimum spice measurement of one teaspoon with a tolerance of plus or minus one-tenth of a teaspoon. To remain relevant to the accessibility goal, it will also need to operate through a touch screen interface featuring large buttons and an intuitive design that is learnable with minimal effort.

Overall, this project is very feasible. All of the constraints mentioned above are manageable with the right amount of planning and effort.

3 Literature and technical survey

While S.P.I.C.E. is not the first of its kind by far, the intentions behind it are what make this project unique. There have been several takes on this style of project already, each with their own pros and cons. *TasteTro [4],* The *Automatic Spice Dispenser [5], Spicer [6], MeasureMINT [7],* and *Fab Academy Final Project [8]* all feature similar designs to S.P.I.C.E.'s original solution. However unlike the past solutions, S.P.I.C.E. is intended as an accessibility tool. With this in mind, this project will need to emphasize focus on a simplified user experience.

TasteTro [4]

TasteTro is the most commercial implementation similar to this project. It's also been commercially advertised since January 2018, and has received multiple patents in the US, Canada, and Australia. The most substantial difference between TasteTro and S.P.I.C.E. is their options for distribution. S.P.I.C.E. is intended to incorporate both recipe and individual spice selection capabilities, whereas TasteTro appears to operate exclusively on predetermined recipes. One aspect of TasteTro that S.P.I.C.E. may take inspiration from would be the spice storage and distribution mechanism, which is a clever cartridge based design. Another admirable aspect of TasteTro's design is its simple three button user interface.

Figure 1: TasteTrio Colorways

Automatic Spice Dispenser [5]

Jeffrey Wang was a mechanical engineering student at UCLA. His senior design project, Automated Spice Dispenser, is very similar to the S.P.I.C.E. It includes a dispenser for up to ten spices, a maximum dispensing time of 10 seconds, and is accurate to within a tenth of a gram. The project also includes pre-programmed spice mixes. Some secondary goals of Jeffrey's project were low spice warnings, manual spice dispensing and a user interface. The rough model of his product is shown below in figure 1:

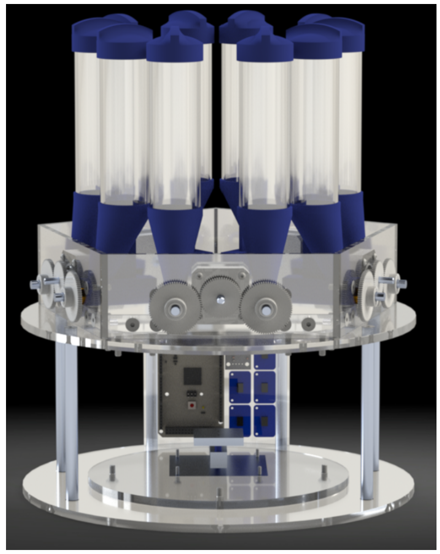


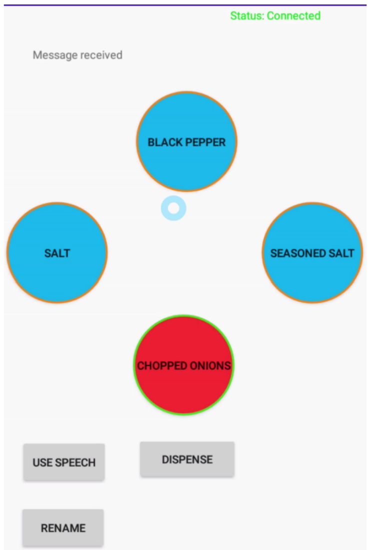
Figure 2: Wang's visualized project design for the Automatic Spice Dispenser

A point for S.P.I.C.E. to improve upon could be the user interface since this dispenser does not have any kind of user interface. Additionally, other improvements could include the addition of spice mixes programmed for specific meals. There was more focus on the fabrication of components and mechanisms since Wang's project was a mechanical engineering based capstone. As computer engineering students, it would be in our best interest to emphasize on the electrical and software components of our project.

Spicer [6]

The "Spicer" is one of the most exhaustive senior design projects we have found related to automated spice dispensing. It has vast functionality and includes many ideas that we were planning on implementing in our own project. It is capable of holding up to 8 spices.

This senior project has an extensive hardware and software design. The hardware design included three microcontrollers that controlled various aspects of the device. The software design included a mobile app which allows users to interact with the device via their smartphone. One of the biggest feats this project accomplished is utilizing machine learning to let users control the device with hand gestures.



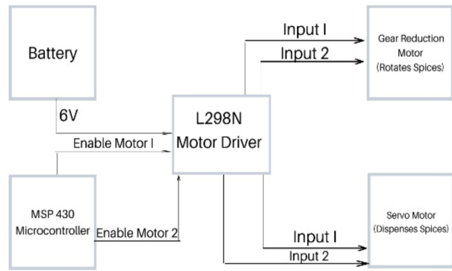


Figure 3: Main UI of the Spicer (left) and flowchart of the hardware design (right)

The team working on this project set ambitious goals, many of which were not fully completed in the first prototype. However, by the second prototype the team was able to implement most features they wanted into the project. One thing S.P.I.C.E. can improve on is the ability to web scrape recipes online and figure out what spices are needed. The team originally planned for "Spicer" to be able to do this but were not able to fully implement this feature at the end of the project.

MeasureMINT [7]

The MeasureMINT is an automatic spice dispenser that is capable of dispensing single quantities of spices based on the user's preference. It can hold up to twelve spices and can dispense spices in various quantities based on user input with a touchscreen, which is similar to S.P.I.C.E.'s proposed functionality. Some future goals that the creator mentioned were voice recognition and the ability to dispense multiple spices at a time. The creator's product is shown below in figure 4:

Figure 4: MeasureMINT

There is a recipe option shown on the UI in the demonstration for the product, but it is uncertain how exactly it works and what components are involved in that aspect of the MeasureMINT. The

S.P.I.C.E.'s goal is specifically to account for recipes and potentially include a networking component such that the product can scrape data from a website and dispense spices based on spice keywords that it is able to retrieve. Another improvement would be related to the UI functionality. The demonstration shows that it may be time consuming for the user to input their data into the system, and one particular goal of S.P.I.C.E. is to make the seasoning process efficient and not tedious.

The proposed S.P.I.C.E. design is expected to be faster than MeasureMINT, as it is planned to have a more efficient process for dispensing spices. It will also have more unique functionality compared to MeasureMINT, especially with the web scraping component for recipes.

Fab Academy Final Project [8]

Fab Academy is a 20 week program with a specialization in prototyping and planning with a distributed education model. One of Muhammed's final projects was a spice dispenser as shown below.

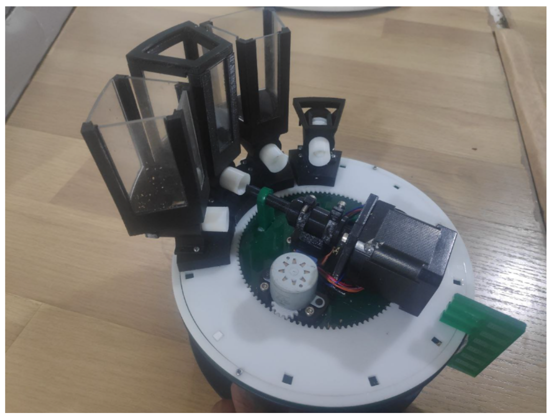


Figure 5: Fahiz Spice Dispenser

This project is similar to the measureMINT project, as it uses a single motor to rotate spices and a sliding shaft to connect a motor to the dispensing mechanism. Some downsides to this product are that it rotates and dispenses slowly, doesn't contain a UI, and no specific measurements are taken into account.

Conclusion

Whilst these products have similar components to what S.P.I.C.E. plans to incorporate, S.P.I.C.E. intends to resolve some of the issues these products were experiencing or incorporate the features that some of these products were missing. For instance, there were some products that did not incorporate accurate measurements or a UI, and there were other products that were just inefficient. S.P.I.C.E.'s goal is to ensure that those problems are addressed alongside taking into account the needs of cooking.

4 Proposed work

4.1 Evaluation of alternative solutions

- Use rotating mechanism to house spices
  - The original idea for S.P.I.C.E.'s housing system was a linear design where each spice had its own distribution unit and all units connected with tubing to guide distributed spice to the desired location. After researching alternative solutions, using a circular, carousel-style, design appears to be the most efficient choice for organization. Although a circular design will require more space, it will also simplify software development aspects by eliminating the need for multiple distribution points.

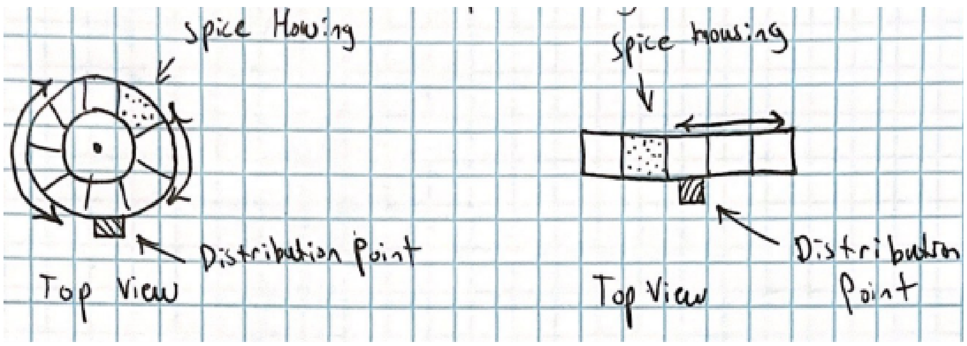


Figure 6: Rough sketch of alternate mechanisms

- Use corkscrew mechanism for spice distribution
  - The corkscrew dispensing mechanism was used in multiple projects found during the technical survey. In the Automatic Spice Dispenser [] , this system utilized a motor and 3D printed corkscrew for each individual spice housing. This approach would increase the overall cost of our prototype and is not advisable. However, the measureMINT and FabAcademy projects both improved on this design by utilizing a sliding shaft that could be connected to and retract from each spice housing. This reduced the overall number of motors necessary to implement their spice dispensing systems. While this seems like the most viable option, the mechanical design aspect of this mechanism may prove challenging in tandem with the rotating spice mechanism.

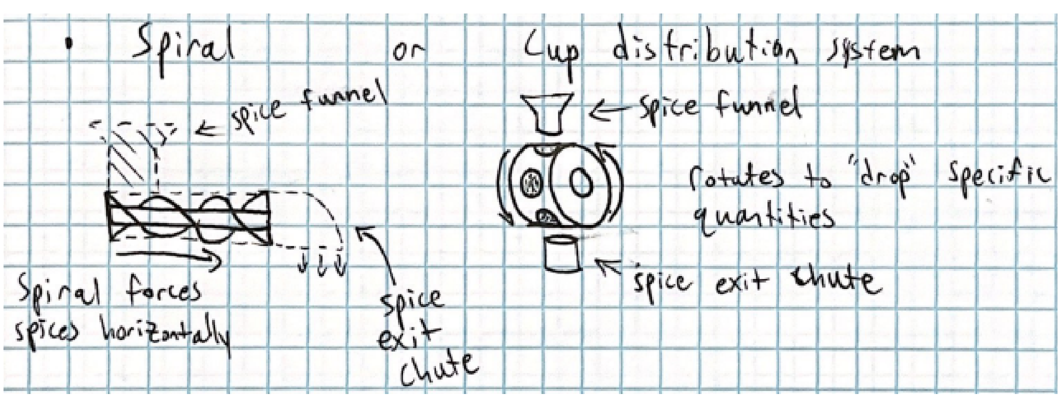


Figure 7: Rough sketch of distribution mechanism ideas

- Support recipe options and individual spice options
  - The ability to support recipe options would be a very useful feature for those who need multiple spices mixed together. This functionality will parse a recipe that is input by the

user and figure out all the spices required. Parsing recipes will save time because the user won't have to run S.P.I.C.E. multiple times if they need multiple spices. This route also saves effort on the user end since the user doesn't have to know exactly what spices they need because the device will figure it out for them. Both options could be implemented into the device for maximum versatility. By adding an option to input recipes, S.P.I.C.E. will have an advantage over other products of this nature since many of them only dispense spice based on what the user wants.

- Mobile application vs. interface attached to device
  - Using a mobile application for controlling the device has a major upside in the form of convenience. Users don't have to be right in front of the machine in order to use it. A downside to this option is since the product is geared towards elderly or those with motor impairments, it could be the case that they don't own a smartphone or find smartphones hard to use. By using an interface attached to the device it eliminates the need for an external device to control the S.P.I.C.E. It is slightly less convenient since the user will have to be in front of the device. Lastly, the team concluded the interface on the device will be easier to implement versus a mobile application. Therefore, it has been decided that S.P.I.C.E. will have an interface attached to the device.

- Voice recognition capability
  - The final alternative option would be to have a voice recognition feature alongside the UI. The user can simply tell the machine what spices they want to dispense or what recipes they want to follow, as well as the spice measurements they wish to take (less button-pressing for measuring spices). A significant advantage to this feature is efficiency, as it would greatly reduce the need to be constantly pressing buttons to input data into the system. One particular goal of S.P.I.C.E. is that it should be easy to use, which this feature is intended to achieve. However, a particular disadvantage to this feature is that it doesn't consider people who are deaf, as they would not be able to speak into the system, and it might also be a difficult implementation.

4.2 Design specifications

Spice Block Diagram:

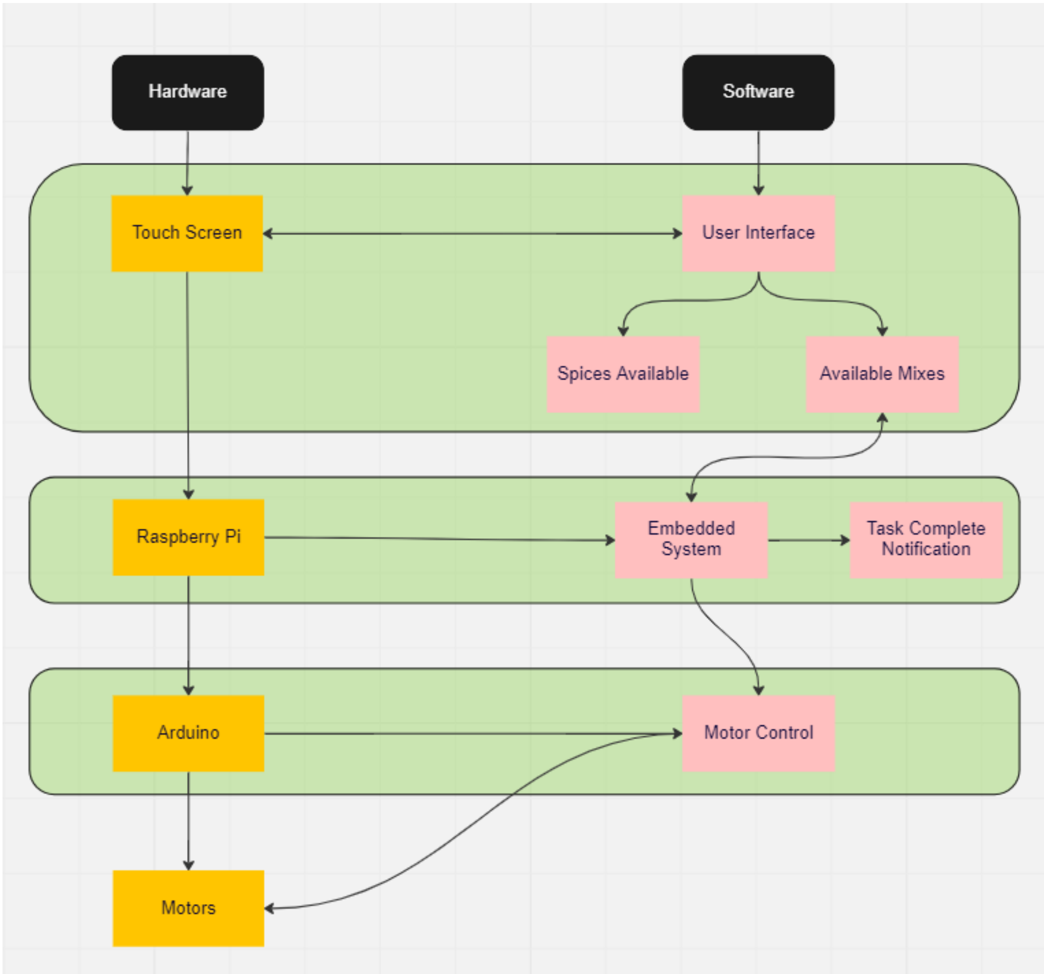


Figure 8: High Level Block Diagram

The design of S.P.I.C.E. is based around the major hardware and software components. These are broken up into modules as shown below:

Touch Screen:

The touch screen acts as the main point of contact for users. It will display the user interface, and allow for users to interact with S.P.I.C.E. This is a key component of the project and will differentiate it from a few of the others from the literature review

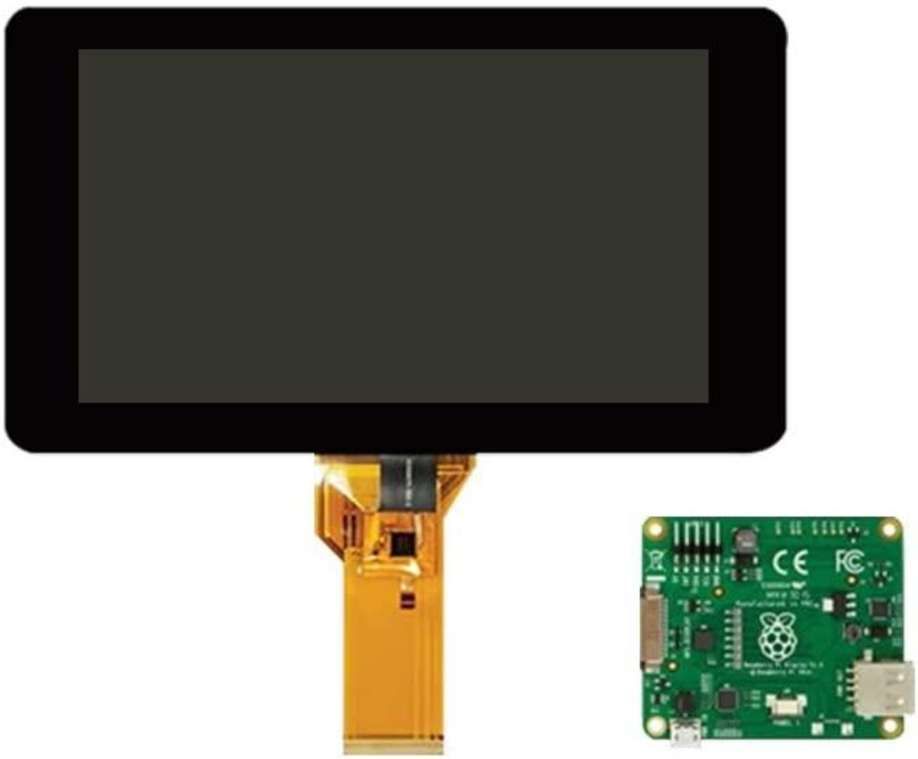


Figure 9: Touch Screen Component

Interface Buttons:

An alternative solution to the touch screen interface is physical buttons. This will give tactile feedback to users, making the interface more responsive.

Raspberry Pi:

The Raspberry Pi will be the brains of the device. It will give the user interface functionality on the back-end. The Raspberry Pi will also process human interactions and send the data to the Arduino which then controls the servo motors.

Arduino:

The Arduino will serve as the controller for all the servos and motors throughout the device. It will receive instructions from the Raspberry Pi on which servo motors to activate depending on the user input from the touch screen interface.

Motors:

The orientation motor will control which spice is being dispensed at a given time, while the distribution motor will drive the actual mechanism that accurately dispenses each individual spice for the user. Orientation and distribution are used as identifiers in this case and do not relate to any technical term for a type of motor. These motors will receive instructions exclusively from the Arduino microcontroller.

User Interface:

The User Interface (UI) is a key feature for accessibility and also serves as a point of interaction for users. Along with the touch screen, the UI provides all the necessary functionality needed for the user to record their data into S.P.I.C.E. for desired results. The user will be able to choose between two different options: “Recipes” and “Spices”. The “Recipes” option will be designed specifically for recipes on the web. Once a recipe is selected by the user, the UI will then display a summary of the recipes to be dispensed after parsing is complete. The user can then confirm that those are the correct spices, and then the system will dispense the spices as instructed. The “Spices” option accommodates users who just want to dispense custom quantities of spices, which is entirely independent of recipes. Upon selection, the UI will prompt the user to select the spices they intend to dispense. After the user selects their spices, they will be able to input the amount in teaspoons of each spice they want to dispense from the machine. Once that is done, A diagram of the user interface structure is shown below:

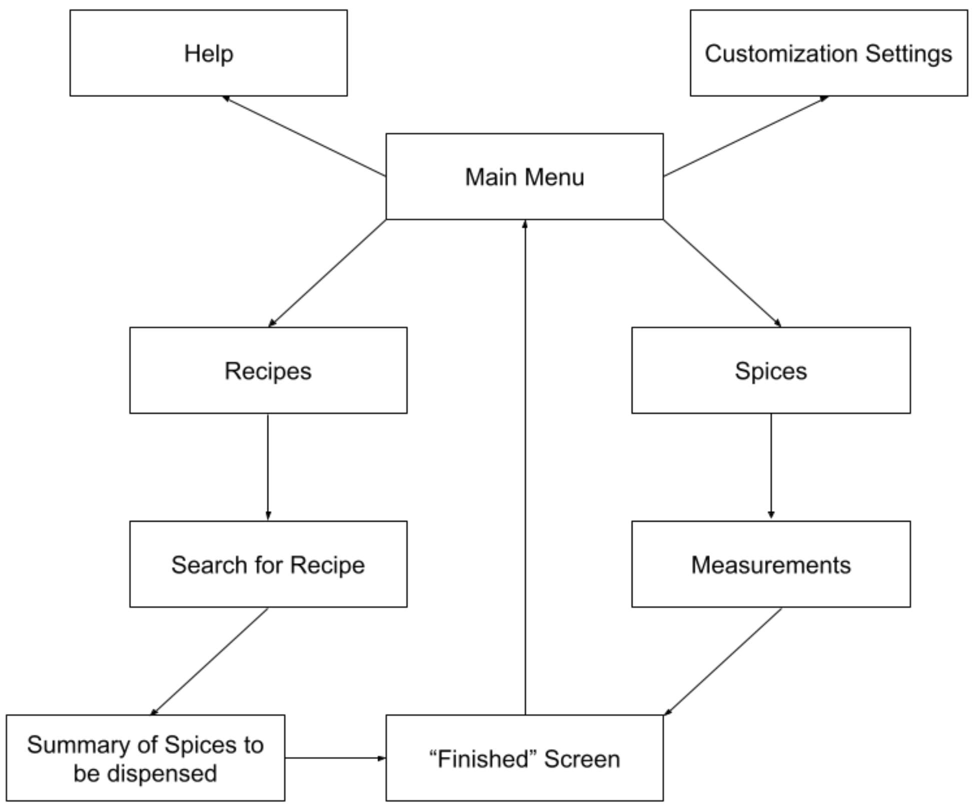


Figure 10: S.P.I.C.E. User Interface

This project can be broken into two major elements: the hardware and the software. Ideally, this project can be executed with as little as: a motor controller, motors, well designed spice containers, and a previously mentioned carousel mechanism.

For the moment, the goal is to utilize a raspberry pi to handle human interactions through the touch screen module. Then, translate those interactions into necessary instructions for the Arduino to interpret and relay to the corresponding motors.

4.3 Approach for design validation

The validation process for S.P.I.C.E. will consist of multiple stages throughout the duration of development. This method is essential for successful development in the sense that waiting until the project is “finished” to perform testing could cost time if a major issue or bug is discovered as it would be difficult to pinpoint the exact location of the bug due to there being many components to examine. This method is organized in such a way that there are multiple factors to consider when designing this product based on the objectives and constraints the team set forth for this project. Such factors include accuracy, environment, and usability/accessibility.

The first round of tests will consist of ensuring that the UI meets the team’s standards and constraints, as well as testing the hardware and mechanics of the system. Upon completion of the UI, it will be tested for accessibility and usability by recording the average time it would take to input data into the system as well as testing the functionality of each of the buttons and ensuring that they do what they are supposed to. The hardware testing process will include tests to ensure that the base components themselves are working properly (motor, touchscreen, Raspberry Pi). This aspect is important to consider, or else there wouldn’t be a working product since S.P.I.C.E. relies heavily on hardware to operate.

Durability will be another factor to perform tests on. In other terms, the team will perform tests on the product in the environment it is designed to operate in, which is a kitchen. These tests will be based on temperature and if the system doesn’t physically malfunction at a normal kitchen temperature (65-75°F). The validation process in this category will consist of observing the behavior of the motors in the system. Since one of the main aspects of S.P.I.C.E. is for it to be a household kitchen product, durability is an important factor to take into consideration when validating the design of the product.

Accuracy is another important feature to test. This will require the hardware to be synchronized with the UI and touch screen. Tests will be performed on the system by taking various measurements of spices through user input and comparing the measurements generated by S.P.I.C.E. with handmade measurements in teaspoons. The margin of error between the two measurements must be no greater or no less than a tenth of a teaspoon. This is a critical aspect to validate, especially for the quality of food and recipes.

Finally, there will be a round of testing with the fully integrated system. While the components of the system would be individually validated beforehand, it is still crucial to test S.P.I.C.E. to its fullest potential to ensure that it is a product that satisfies the team’s goals and solves the main problem identified by the team. More specifically, S.P.I.C.E. should function in a way that it makes cooking enjoyable for people who are living alone and those with motor disabilities. This means that it should be usable, accessible, operational, and accurate. These four main qualities will be accounted for when executing the final rounds of testing.

5 Engineering standards

5.1 Project management

Role	Member(s)
Project Manager	Carlos Zapata III
Mechanical Design	
• Component Modeling • Material Acquisition • Hardware Placement	• Caleb Herrera, Carlos Zapata III • Carlos Zapata III • Caleb Herrera
Software Design	
• UI Designer • Microcontroller Specialist • Hardware Networking	• JP Bartsch • Kile Zimmermann • JP Bartsch, Kile Zimmermann
Validation Lead	JP Bartsch

After discussing individual strengths and weaknesses, the team has organized itself into the roles above. Below are some qualifying attributes of each member and their role in the project

With previous management experience in both academic and extracurricular activities, Carlos Zapata has been chosen to be project manager. The responsibilities of this position will include maintaining organization items such as: Gantt charts and burndown charts, as well as scheduling meetings. Additionally, Carlos will be assisting lead CAD designer Caleb Herrera with the design and fabrication of the mechanical components of S.P.I.C.E.

Caleb will be responsible for managing progress on hardware related tasks. He also has previous outside experience with Computer-aided Design (CAD) and arduino/raspberry pi style projects, so he will be contributing heavily to any microcontroller systems and 3D modeling when necessary.

JP has experience with front-end development and database systems and will manage the progress of the software design as well as designing a possible database to store all the recipes and designing a user interface. He will also be in charge of testing the product and integrating the touch screen with the software. This will include working on an easy-to-use interface that minimizes button-pressing as much as possible for convenience.

Kile has past experience utilizing Raspberry Pis for projects and has an interest in embedded systems. He will primarily contribute to the microcontroller systems aspect of the project alongside Caleb. Another key responsibility of this position is interpreting schematic diagrams for various circuit components that will be used throughout the project to ensure they are being used correctly and optimally.

The team has agreed to hold regular weekly meetings every Friday. These meetings will include project updates and discussion on individual roadblocks. The addition of a meeting time outside of lecture gives the team flexibility with scheduling while maintaining a constant workflow. Due to its ease of access in a shared drive, tasks and the team's burndown chart will be updated based on a Google Sheets Gantt chart. This gives each team member the ability to track their progress individually and update the team during Friday meetings. Communication that is not in person will generally be held on a team CSCE 483 discord server. Documentation for all meetings will be recorded in personal notebooks, the team google document, and Discord instant messages. Maintaining documentation in three places will ensure that no design, idea, or personal thought is left out of discussion.

5.2 Schedule of tasks, Pert and Gantt charts

Tasks:

WORK BREAKDOWN STRUCTURE	TASK TITLE	TASK OWNER	AMOUNT OF WORK IN HOURS			SPRINT	START DATE	DUE DATE	DURATION
			ESTIMATE	COMPLETED	REMAINING				
1	Proposal		73	14	59				
1.1	Project Proposal	ALL	10	8	2	0	2/13/2023	2/15/2023	3
1.1.1	Presentation	ALL	6	4	2	0	2/13/2023	2/15/2023	3
1.2	General Design of Parts	ALL	10	2	8	1	2/16/2023	2/22/2023	7
1.3	Gather Parts	Carlos	3	0	3	1	2/16/2023	2/22/2023	7
1.4	Draft Design of Mechanical Components	Caleb, Carlos	12	0	12	1	2/16/2023	2/22/2023	7
1.5	Draft Design of UI	JP	16	0	16	1	2/16/2023	2/24/2023	9
1.6	Draft Design of Microcontroller	Kile	16	0	16	1	2/16/2023	2/24/2023	9
2	Design		46	0	46				
2.1	Finalize Motor Mechanism	Caleb,Carlos	12	0	12	2	2/22/2023	3/1/2023	8
2.2	Finalize Sliding Shaft	Caleb,Carlos	12	0	12	2	2/22/2023	3/1/2023	8
2.3	Begin working on UI	JP	22	0	22	2	2/26/2023	3/8/2023	11
2.4	Begin work on Arduino	Kile	22	0	22	2	2/26/2023	3/8/2023	11
3	Fabrication		120	0	120				
3.1	Fabricate Rotating Base	Caleb, Carlos	12	0	12	3	3/1/2023	3/6/2023	6
3.1.2	Fabricate Housings	|	12	0	12	3	3/5/2023	3/10/2023	6
3.1.3	Fabricate Dispensing Mechanism	|	18	0	18	3	3/19/2023	3/27/2023	9
3.1.4	Atatch Motors	V	6	0	6	3	3/27/2023	3/29/2023	3
3.2.1	Finalize UI	JP	30	0	30	3	3/8/2023	3/24/2023	17
3.2.2	Integrate Touch Screen	JP, Kile	12	0	12	3	3/24/2023	3/29/2023	6
3.3	Finalize Arduino Functionality	Kile	30	0	30	3	3/8/2023	3/29/2023	22
4	Validation		127	0	127				
4.1	First Round Validation	All	16	0	16	4	3/29/2023	4/5/2023	8
4.2	Fix Mechanical Issues	Caleb, Carlos	20	0	20	4	4/5/2023	4/13/2023	9
4.3	Add Spice Mix functionality	JP, Kile	16	0	16	4	4/10/2023	4/17/2023	8
4.4	Second Round Validation	All	15	0	15	4	4/17/2023	4/21/2023	5
4.5	Final Fixes	All	30	0	30	4	4/21/2023	4/28/2023	8
4.6	Final Round Validation/Updates	All	30	0	30	4	4/21/2023	4/28/2023	8

Figure 11: Schedule of Tasks

The tasks above are broken down into five sprints:

1. Proposal (Sprint 0)
2. Drafting
3. Design
4. Fabrication
5. Validation

Proposal:

The first "sprint" (#0) of S.P.I.C.E. project development is the proposal of the idea. This includes background research for the problem and need, as well as a presentation of what S.P.I.C.E. aims to accomplish. This formal proposal is part of that sprint, and will be the last completed task of "sprint 0".

Drafting:

This sprint (#1) encompasses the first rough planning phase of the project. There are multiple mechanical components that need to be thought out and hand sketched before they are transferred to a CAD software. The 3D modeling process will be significantly smoother if all of the parts already have a physical sketch to go off of. Given that no one on the team has a distinct background in mechanical development, it's important to give adequate time to the development of the mechanical components of this project.

Additionally during this sprint, the main software developers will begin drafting the S.P.I.C.E. UI and considering how the microcontroller and processor will be utilized for motor control.

Design:

The **Design** sprint (#2) will mark the beginning of tangible development. Mechanical components will be designed in 3D modeling software and imported into CAD files. Development on both the UI and microcontroller programs will begin. During this sprint, there is no expectation that the components, UI, and microcontroller will be completely finished by the end date. Because all three components can be developed independently, there are no critical paths in this sprint. This gives each development group the ability to work on their assigned task without worrying about how it will hold up any other tasks.

Fabrication:

Fabrication of physical components is set to begin around the beginning of March. This will be the main critical task for this sprint. Without the components, there will be nothing to test the motors, hardware, and software on. Therefore, it is essential that fabrication is completed prior to the completion of the UI program, RaspberryPi, and Arduino Integration. If the Software/Hardware team is ahead of schedule before the completion of the sprint, more resources may be allocated towards fabrication to make sure it is completed in a timely manner.

Validation:

At this point, most of the functionality of S.P.I.C.E. should be complete. This sprint will be entirely dedicated to meeting all set objectives and constraints. Time in this sprint can also be used to fix any additional issues with the S.P.I.C.E. prototype. There are multiple rounds of validation, each with a different focus. The first being mechanical operation, the second being UI and hardware operation, and the final being a general validation. There is also time allotted at the end of this sprint to allow for work on a final report and presentation.

Noteworthy Critical Paths:

- Fabrication of housings and mechanical components
- UI & Arduino Functionality
- Integration of the touch screen
- Spice Mix functionality

Scheduling and Gantt Chart:

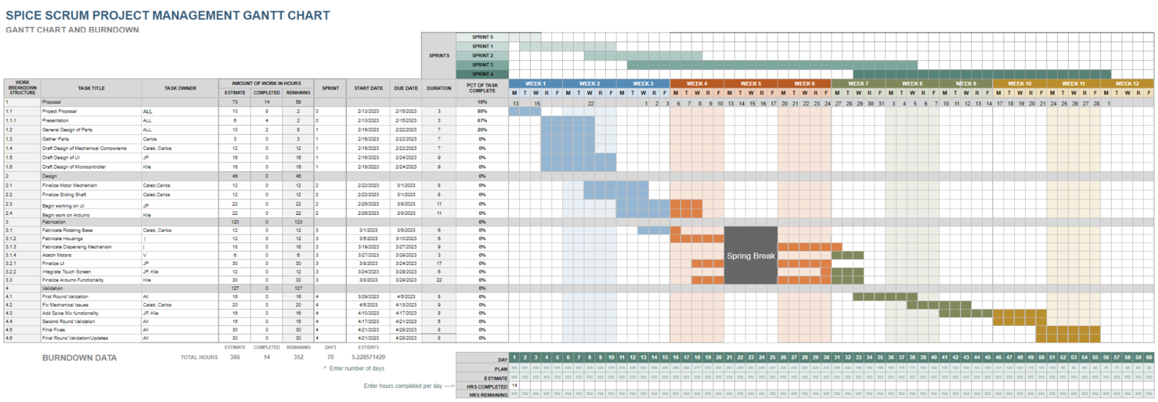


Figure 12: Gantt Chart

5.3 Economic analysis

Economical Viability

S.P.I.C.E. will potentially be a highly marketable product to the community. While S.P.I.C.E.'s competition may be extreme, it still has potential to become a popular product as some similar products contain features that other products don't, and S.P.I.C.E. intends to take inspiration from those products as a whole and combine those features to become one product. This product is beneficial in the sense that it mainly simplifies the difficult cooking process for elderly people living alone and motor disabled people. This system eliminates the need for these people to physically take spice measurements and dispense spices themselves. Since this product relies heavily on hardware and no pecuniary resources are needed for the software besides a touchscreen, the initial cost is moderate.

Sustainability

Many of the parts used in the S.P.I.C.E. prototype will be commercially available from multiple vendors. This means that parts should be available and ready to replace in the event that anything happens with them. This also means that repairs on the S.P.I.C.E. should be fairly straightforward as long as nothing disrupts the Raspberry Pi and Arduino boards.

Manufacturability

Component tolerances are a major concern for this project. The custom designed distribution mechanism will need to consistently distribute the correct amount of spice. Similarly, alternating between spices leaves opportunity for two spices unintentionally mixing if components aren't properly fabricated. Worst case the project fails to keep spices separated, when not in use, or doesn't dispense accurate spice quantities. Finally as a food related product, this project will have to abide by any laws and regulations for kitchen appliances.

5.4 Societal, safety and environmental analysis

Societal Analysis:

This project aims to benefit society by improving the quality of life of persons with motor disabilities. If executed correctly, this project should not breach users' privacy or pose any risk to the physical well-being of users. S.P.I.C.E. is a product that is expected to encourage cooking in the sense that it simplifies the process for all demographics and not just motor disabled people. It makes cooking less tedious for people since it eliminates the need to manually measure out spices when seasoning food. S.P.I.C.E. is expected to greatly improve the quality of food and reduce the amount of error in seasoning food, which will promote the well-being of people.

Safety Analysis:

To avoid personal injuries, the S.P.I.C.E. will be designed in such a way that hides all critical and potentially dangerous components within its container. Not only does this protect the various components from outside damage, but also protects the user when interacting with the device. When building the device, we will ensure that all components are fastened tightly and neatly organized within the container to avoid potential breakdown of the device which could endanger the user.

Environmental Analysis:

Finally, this product should not have any impact on the environment, as it is a household product and should not contribute to existing environmental issues such as pollution. One particular aspect of the project that can exercise sustainability is the 3D CADing. Many brands use printing material that is recycled plastic which is much better than using normal plastic. The team will try and only acquire printing materials from brands that use recycled plastics.

5.5 Itemized budget

Item	Quantity	Cost Per Item	Total Cost
Servo Motors	2	$14.99	$29.98
ESP32 WROOM	1	$11.00	$11.00
Raspberry Pi Touch Screen	1	$108.00	$108.00
Raspberry Pi Zero W	1	$74.95	$74.95
Brown PLA 1.75mm (1kg)	1	$19.99	$19.99
High Torque DC Motor	1	$30.72	$30.72
Total			$274.64

6 References

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7 Appendices

7.1 Product datasheets

Raspberry Pi 4 Model B

https://datasheets.raspberrypi.com/rpi4/raspberry-pi-4-datasheet.pdf

MG995 Servo Motor

https://www.electronicoscaldas.com/datasheet/MG995_Tower-Pro.pdf

ESP32 WROOM

https://www.espressif.com/sites/default/files/documentation/esp32-wroom-32_datasheet_en.pdf

7.2 Bios and CVs

JP Bartsch is a senior Computer Engineering major at Texas A&M University with a Mathematics minor. During his time at Texas A&M, he has learned about important programming languages (C++, Java, Python) and database management with SQL and PHP. He participated in AI4ALL, an AI based program, where he worked in a team to develop a "Baseball Player Performance Approximator" which would simplify a complex statistic in baseball with the use of ML algorithms (KNN, Lasso, Elastic net). JP plans to graduate in May 2023 and hopefully obtain a career in software/systems development or database design.

Caleb Herrera is a Computer Engineering student at Texas A&M University, also minoring in Mathematics. Caleb plans to graduate May 2023 and pursue a career in Cybersecurity. Over the summer of 2022, Caleb interned as a Summer Engineering Analyst in the Global Markets Tech Risk division at Goldman Sachs. He would like to someday specialize in incident response or ethical hacking. For the meantime, he is open to a broad range of entry level Cybersecurity positions to gain experience while pursuing certifications.

Carlos Zapata III is graduating in May 2023 with a Bachelor's in Computer Engineering. During the summer of 2022, Carlos interned with General Motors and had the opportunity to work with the manufacturing quality team and AI vision group. He intends to continue to pursue his interest in computer vision and is considering a Graduate degree related to AI in the future. Currently Carlos has accepted a full-time offer with General Motors and will be returning to work in July 2023.

Kile Zimmermann is a senior Computer Engineering student at Texas A&M University with a Mathematics minor. Kile plans to graduate in May 2023 and start his career in software engineering. As of writing this paper, he has accepted a job offer with Lockheed Martin in Fort Worth TX, as a Software Engineer that will specialize in F-16 systems.

John Paul Bartsch

22410 Sawston Drive | (281)-793-0411
Tomball, TX 77375 | johnpaul.bartsch@gmail.com

Summary

Passionate and diligent college student working towards a Bachelor of Science degree in Computer Engineering at Texas A&M University. 3+ years' experience with programming languages such as C++, Java, and 1 year with web development. Currently seeking out software development positions and opportunities to apply what I have learned so far to contribute to those positions.

Education

Texas A&M University, College Station, TX — **May 2023**

- Pursuing Bachelor of Science degree in Computer Engineering with a minor in Mathematics
- Cumulative current GPA: 3.49/4.0

Relevant Coursework

- **Completed** – Introduction to Computer Systems, Microcomputer Systems, Programming Studio, Database Systems, Communications and Cryptography I, Design and Analysis of Algorithms
- **In Progress** – Computer Systems Design, Communications and Cryptography II, Foundations and Applications of Blockchains

Projects

Personal Website — **February 2022**

- Assimilated HTML, CSS, and JavaScript to design a personal website with various unique functionalities

Baseball Player Performance Approximator — **August 2021 – December 2021**

- Participated in a 3-person team to devise an efficient way of predicting performance of baseball players on a season-to-season basis; utilized machine learning algorithms and AI concepts, as well as datasets

Layne's Inventory Management System — **February 2022 – March 2022**

- Worked with a 4-person team to construct a mock inventory management system for Layne's restaurant in Texas; incorporated waterfall development methodology, SQL, and Java

Morse Code Translator — **January 2022 – April 2022**

- Worked in a 2-person team to design an embedded system translating morse code into characters by detecting a certain sequence of push button presses and outputting a corresponding character to an 8x8 matrix

Newvie — **March 2022 – May 2022**

- Front-end developer in a 3-person team; created a web application recommending a movie or TV show for users to watch based on user input

G7 Tutoring — **August 2022- December 2022**

- Participated in a 4-person team to design a functional tutoring web application using database concepts, PHP, and MySQLi

Work Experience

IT Intern – Frassati Catholic High School, Spring, TX — **June 2022 – August 2022**

- Performed tasks for the IT department to get technology started up and running for the upcoming school year, as well as ports, switches, getting laptops onto the school domain, etc.

Organizations

Apply AI — **August 2021 – December 2021**

- Project-based program designed to integrate what was learned from a previous introductory program and use those skills to design a project with mentorship from a professional in AI

Changemakers in AI — **December 2021 – Present**

- Serves as an "alumni" community for people upon completion of the Discover AI and Apply AI programs, and provides internship and mentorship opportunities

Awards

Distinguished Student Award — **August 2020 – December 2020**

CALEB HERRERA

calebherrera2019@gmail.com • (512) 993-6434 • www.linkedin.com/in/caleb-herrera

EDUCATION

Texas A&M University | Bachelor of Science in Computer Engineering | May 2023
Minor: Cybersecurity, Mathematics
Overall GPA: 3.39

EXPERIENCE

Goldman Sachs – Dallas, TX | June 2022 – Aug 2022
Tech Risk Engineering Summer Analyst

- Automated daily reporting process, cutting down execution time from over an hour to less than three minutes
- Developed a Tableau dashboard to dynamically reflect state, and metrics, of programs managed by team
- Supported team operations by performing several data analysis tasks utilizing SQL, Python, and Alteryx Designer

RELEVANT COURSEWORK

CSCE 465 Computer & Network Security – | Fall 2022

- Studied concepts and principles in Operating System security, Network security, Web security, and Cryptography
- Designed exploits utilizing buffer overflow, SQL injection, ARP Cache poisoning, and SYN Flooding
- Leveraged virtual machines to simulate multiple computers on the same LAN for network vulnerability analysis

ECEN 424 Fundamentals of Networking – | Fall 2022

- Studied aspects of the OSI model including physical, data link, network, and transport layers
- Simulated a server that hosted up to 10 clients simultaneously over a TCP connection using Java and multithreading

ACTIVITIES

Texas A&M Cybersecurity Club – College Station, TX | Fall 2021
Member

- Engaged in weekly meetings covering topics in network/system defense, web exploitation, cryptography, etc
- Attended presentations on Cybersecurity career opportunities given by industry speakers from a range of companies
- Awarded a certificate of completion for the Red Hat Alliance System Administration I course

Texas A&M Howdy Hack – College Station, TX | Fall 2021
Competitor

- Competed in a 24-hour long competition hosted by Texas A&M University in a team of four students
- Designed a student productivity app focused on time management, convenience, and integration with student portal
- Developed a prototype using skills learned in competition including Figma and the Tkinter Python module

LEADERSHIP

Solar Car Challenge – Fort Worth, TX | Summer 2019
Co-Team Leader/Competitor

- Headed a team of 16 high school students to compete in national Solar Car Challenge at Texas Motor Speedway
- Oversaw weekly meetings to engage students in testing and modifying solar car for optimal performance
- Placed 5th in the Advanced Classic Division after completing 234 laps, totaling 351.0 miles driven

SKILLS

- Proficient in C++, Java, and Python
- Familiar with Windows and Linux
- Familiar with ARMv8 Assembly

CERTIFICATIONS

- Alteryx Designer Core
- Autodesk Inventor

Carlos Zapata III

Austin, TX | 512-695-9030 | czapata9030@tamu.edu | https://github.com/czapata9030
https://www.linkedin.com/in/carlos-zapata-iii/

EDUCATION

Texas A&M University — College Station, Texas
Pursing Bachelor of Science in Computer Engineering — Expected Graduation: May 2023
GPA: 3.57/4.00

Honors**:**

- *President's Achievement Award*
- *National Hispanic Merit Scholar*

EXPERIENCE

General Motors | Information Technology Software Intern — May '22 – August '22

- Tasked with the development of a **TFS dashboard** that displayed and actively updated code coverage of team services.
    - Covered **.NET** repositories and used **bash scripts** to run CI/CD pipeline agents
- Designed and documented a reproducible process for publishing code coverage to **DevOps server**

Research | *Performance of Superalloys under Non-Isothermal Loading Conditions* — January '22 – May '22

- Research with Texas A&M Aggie Research Program
- ***Systems Engineer:***
    - Responsible for programming DAQ on experimental test rig

PERSONAL PROJECTS

Stagelight: — December 2021

- **Web application** designed to match small music artists with local venues
- Created with **Angular** HTML framework and **Firebase** Realtime Database
- Allows users to preview artist's music with **YouTube API**
- Uses Ticketmaster and Bandsintown APIs to **display show listings**

Movie Recommendation System: — October 2021

- Worked in small development team to produce movie recommendation system utilizing **AWS database**
- Over 700,000 data entries based on related titles, actors, directors, and user ratings
- Utilized **SQL queries** for recommendation algorithms

Personal Website: http://people.tamu.edu/~czapata9030/ — September 2021

- Designed from scratch using Bootstrap HTML, CSS, and JavaScript

SKILLS

Technical Skills:

- **Most Proficient: Front-End Development**
- Experienced with: C++, Python, JavaScript, Git, Azure DevOps, Dashboarding
- Exposed to: Angular, React.js, C#, .NET, CI/CD Pipelines
- **Actively improving:** Back-end development & Database Management

LEADERSHIP & ACTIVITIES

TAMU Swim Club — June '20 – January '22

TAMU Triathlon Club — August '19 – June '20

Kile Zimmermann

GitHub / LinkedIn / Projects Portfolio / (512) 644-0641 / kilezisme@gmail.com

Education:

Texas A&M University, College Station, Texas May 2023 Bachelor of Computer Engineering

GPA: 3.455

Activities:

AI4ALL Texas A&M University January 2021 – December 2022 *Member*, January 2021 – December 2022

- Conducted research into many different aspects of AI and machine learning
- Developed a solution to a real-life problem that utilizes machine learning
- Participated in workshops and speeches given by industry mentors

Experience:

Resident Advisor Texas A&M University August 2022 – Present

- Planned, budgeted, and hosted programs/events for residents
- Fostered an inclusive and diverse community
- Enforced dormitory and campus wide rules and policies

Programming Teaching Instructor Online June 2021 – August 2021

- Instructed/mentored many classes of students between the ages of 7-18.
- Class content focused on Scratch, Python, & Java.
- Built positive relationships with students & parents.

Technical Skills:

Front End | JavaScript, React, HTML, CSS, Bootstrap

Back End | Java, Python, C++, Node.js, Express, PostgreSQL

Deployment | Heroku, IBM Cloud

Developer Tools | Git, npm, Waterfall Methodology, Agile Methodology, JSON

Computer Engineering Applications:

Layne's Restaurant Database Management System Java | Java Swing | PostgreSQL

Layne's restaurant DBMS to house order history and inventory data and a corresponding GUI for employees

- Worked with team members to design easy to navigate GUI using Java Swing for restaurant managers/servers
- Leveraged hashmaps to improve application performance and code readability
- Followed Waterfall Methodology to handle new requirements that were introduced weekly
- Implemented ability for CSV file data to be parsed into the database

Pocket Watch Safety App React | JavaScript | Express | Heroku | JSON

Safety app which included: SOS, emergency services map, crime stats, weather forecast, and informational videos

- Developed server side structure to allow for easy frontend integration
- Utilized caching of information to avoid API quota limits
- Followed Agile Methodology to efficiently break down the complexity of the project
- Worked alongside team members to create frontend skeleton for some components

Morse Code Translator Python | Raspberry Pi | Circuit Design | SolidWorks

Embedded system that translated morse code noises into latin characters & symbols

- Integrated a variety of IC chips on a breadboard to create a functioning system
- Used software and hardware components to create a complex system that served a purpose to users