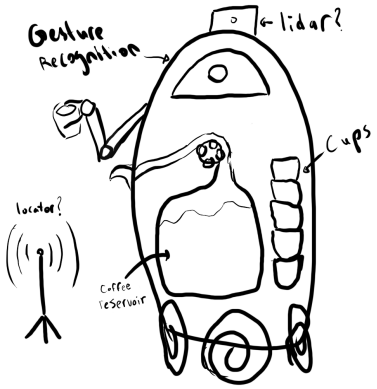
Department of Computer Science & Engineering
The University of Texas at Arlington

Project Charter
CSE 4316: Senior Design I
Fall 2023



MechaMocha
(Product Name TBD)

Hussain Alkatheri
Christopher DeWitt
Bishal Giri
Alexis Hernandez
Phu Truong

Revision History

Revision	Date	Author(s)	Description
0.1	10.06.2023	HA, CD, BG, AH, PT	document creation

CONTENTS

List of Figures

1 Problem Statement

Currently serving arabic coffee is a manual task requiring constant attention of the server or host. Arabic coffee is served in small cups which keep the drink as hot as possible the longest. This is done in order to make the act of drinking the coffee a social event and by lengthening this process it shows that you want the guest to stay as long as possible. These are served generally in rounds going around the room depending on the event and have general standard rules of etiquette.

2 Methodology

In order to automate this process we will be constructing a robot that will serve guests arabic coffee. It will drive across the room looking for guests to serve using its array of sensors. And will use the guests gestures in order to know if they would like to be served, given another round, or to end their service. This will consist of several mechanisms to process the giving and receiving of cups. There will also be a front-end system in order to manage the robot as it serves, providing the operator with important information such as coffee level, current clean cups, current used cups, battery level, etc.

3 Value Proposition

The value proposition is mainly to the consumer which will use the product to accommodate their guests at their homes. Depending on the implementation a enterprise version can be created to sell/rent to businesses for company events. This could increase these companies' reach with middle eastern investors/buyers. This system could also be used at coffee houses providing a unique buffet-style experience. The largest value would be the creation of an iconic product used throughout the middle east and become the symbol of the future.

4 Development Milestones

This list of core project milestones should include all major documents, demonstration of major project features, and associated deadlines. Any date that has not yet been officially scheduled at the time of preparing this document may be listed by month.

Provide a list of milestones and completion dates in the following format:

- Project Charter first draft - October 2023
- System Requirements Specification - October 2023
- Architectural Design Specification - November 2023
- Demonstration of Gesture Recognition - February 2024
- Detailed Design Specification - February 2024
- Demonstration of Coffee Dispenser - April 2024
- Demonstration of Robot Computer Vision - April 2024
- CoE Innovation Day poster presentation - April 2024
- Demonstration of Robot Coffee Dispense- April 2024
- Demonstration of Robot Coffee Handling - April 2024
- Demonstration of Robot Services - April 2024
- Final Project Demonstration - April 2024

5 Background

The goal of MechaMocha is to create a robot that is able to automate the process of serving Arabic coffee while reserving the service that comes along serving Arabic coffee. Arabic coffee is served in multiple rounds with the first round being served to the guests from a waiter that carries a set of warm cups in one hand and a pot of hot coffee in the other. Once the guests have received their first round of coffee, the server would leave to serve other guests and would return later to previous served guests. Once the server returns to the served guests, the guests are able to gesture with their hands using the cup whether or not they would like to be served another round or be done with coffee. With the rise of automation in the service industry, robots are becoming more common in restaurants, taking over the job of traditional waiters. However, with these robots also comes with the shortcomings of a robot as currently the tasks that they're able to do are very limited, ranging from only having limited movement and functions. With MechaMocha, our goal is to create a robot that would be able to reproduce an experience pertaining to Arabic coffee while being able to recognize inputs and provide a service similar to a traditional server. Along with being able to reproduce this experience, currently the costs to purchase a server robot can vary, ranging from 1,000 a month all the way to around 15,000 for a robot. With a budget of 800, we hope to achieve creating a service robot that is able to perform services as well as serve guests for a lower cost. The idea of MechaMocha allows for a bot that restaurants can utilize in the future when it comes to producing a service that guests can interact with and perform it's duties similarly to a traditional server and also saving on costs compared to other robot solutions. With the rising costs of living and workers, the introduction of a robot that can perform services would greatly benefit both restaurants and can begin an expansion towards utilizing robots in industries where services are traditionally done by humans.

6 Related Work

Serving arabic Coffee is primarily an act of hospitality. Adhering to proper rituals ensures a warm, hospitable environment while respecting the art of the serving coffee in the traditional manner. While there have been many advancements in automating such tasks of hospitality and service, very few have been able to entice wide spread interest mainly held behind due to the scarcity products and their associated costs. Currently on the streets of Brooklyn, New York, a robot named ADAM is serving coffee, while interacting with customers and other workers using Generative AI [1]. A $200,000 product by Richtech Robotics isn't just limited to coffee. It's also found in boba shops and bars around the country capable to making around 50 drinks an hour [2]. Famously hired by Kendall Jenner and dubbed "The Kardashian's Bartender", it was featured in season 3 premiere of The Kardashians [3]. However such a price tag is too expensive for our customers, who aren't multimillionares.

Artly, a startup led by a former AWS engineer, recently secured $10 million in funding to develop the new generation of coffee barista bots [4]. In the commercial sector, serving robots are involved as a mere support to ongoing operations, where they handle limited functions. Pudu robots at La Duni and Ari Korean BBQ in Dallas, are used for clearing plates [5] while simaltenously improving marketing appeal through the wow factor. However, these robots have constrained functinalities and cannot carry out the entire service sequence, and require human supervision at all times.

Industry-leading products from Richtech and Artly are beyond the budget for small owned business who cannot afford to invest hundreds of thousands of dollars for a robot to have the same productivity bandwidth with that of a standard paid service worker. MechaMocha steps in with a budget friendly alternative where customers will be provided with competitive performance while being a fraction of the current industry and commercial solutions.

7 System Overview

The coffee serving robot will consist of the following systems: Power system, drive system, communication/control/navigation System, cup serving system, coffee dispensing system, and computer vision system. All systems will be housed within a physical structure sturdy enough to support the weight of the components and tall enough to serve at a table height of 0.8m.

The power system will consist of one or more rechargable batteries connected to appropriate regulators for the other systems. The batteries will be housed low in the structure to keep the robot's cener of gravity as low as possible, and will be secured in a watertight compartment. The batteries will not be charged while in the robot. Instead, they will be easily removed and replaced with a charged set of batteries to minimize downtime.

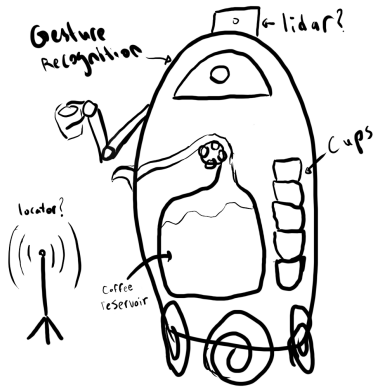
The drive system will consist of two wheels powered by one DC motor each with either a caster wheel or nonmoving low-friction implement used to help maintain balance. Steering will be accomplished by creating a speed differential between the powered wheels.

The communication, control, and navigation system will be the "brain" of the robot. Using data passed to it by the other systems, it will determine where it is, where it needs to be, and how to safely move to its destination. It will pass instructions to the other systems to begin certain operations (move x meters forwards, extend serving arm, stop all movement, etc). It will communicate status messages to the operator, such as indications that it needs a new set of batteries or is running low on coffee.

The cup serving system will extend an arm, platform, or other appropriate implement to serve and take cups of coffee from the end users (customers being served). It will be able to take clean cups from an internal storage area, move them to the coffee dispensing system, and then move full cups safely to within reach of the end users. It will be able to take cups from the user and either move them to the dispensing system or into a storage area for used cups as required. It will move or fold out of the way when not actively being used to improve the robot's ability to manuver.

The coffee dispensing system will consist of an insulated storage container of at least 1L capacity, a food-grade peristaltic pump that is rated for use at temperatures of at least 200 degrees Farenheit, and a spout or tube that is positioned to be within reach of the cup serving system. The amount of coffee dispensed will be controlled to prevent over-filling the cups and to keep track of the amount of coffee remaining.

The computer vision system will consist of at least one camera located at or near the top of the robot and appropriate hardware and software to process images. Data from processed images will be used by the communication, control, and navigation system to aid in navigation decisions and to determine whether or not a guest wants more coffee. There is a possibility that this system will be combined with the communication, control, and navigation system if hardware and software are chosen that can handle both sets of tasks simultaneously.



8 Roles & Responsibilities

The stakeholders for the projects would be the consumers, homeowners and individual who are looking to integrate the technology while maintainig traditional cultural values. In addition, it includes the team that's developing MechaMocha as well as the UTA Computer Science department who are funding the project.

The point of contact would be Hussain Alkatheri who is the product manager. His oversight will ensure that the work is aligned with the projects objectives and expectation of the stakeholders. The team members are Christopher Dewitt, Phu Truong, Alexis Hernandez, and Bishal Giri. The scrum master for the project is going to be INSERT_NAME, where the role is not to change periodically. The projects will involve a lot of moving parts and different Hardware and Software requirements, Chris, Hussain, and Alexis will focus on the physcial components and mechanics of MechaMocha, while Bishal and Phu will take on the software side of things, developing user-interfaces and also implement computer vision to provide the robot with eyes, to recognize and interact with its environment.

9 Cost Proposal

9.1 Preliminary Budget

As the requirements list and product design are still being finalized, only a very high-level approach to the budget has been considered. Machine learning solutions are assumed to be significantly more expensive than other components. Should that assumption be incorrect, a portion of the budget may be reallocated.

Component	**Price**
Jeston Nano and Camera(s)	$400
Everything Else (batteries, motors, other sensors, etc)	$400

Table 1: Component Prices

9.2 Current & Pending Support

Currently, the sole funding source is the University of Texas at Arlington's Computer Science and Engineering Department.

10 Facilities & Equipment

What lab space, testing grounds, makerspaces, etc. will you need to complete the project? Will you require any specific equipment, and if so, where will you get it (borrow, lease, purchase, outsource, already present in the lab, etc.). This section should occupy 1/2 page.

11 Assumptions

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

- The Senior Design Lab (ERB 335) will be available for storage and testing of the robot
- No significant modifications will be needed for the robot to function in the demonstration area
- A working computer vision solution for pathfinding and gesture recognition fits within the project budget
- Hardware capable of running the computer vision solution fits within the project budget

- No obscure local or federal laws prohibit the operation of a robot that serves coffee
- Food service permits are not required for a demonstration, or if they are, they are easily obtainable
- At least one early prototype will be needed to verify design choices and identify problems before construction of the final prototype

12 Constraints

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

- Requirements specifications must be submitted by the end of October 2023
- Architectural specifications must be submitted by the end of November 2023
- Detailed specifications must be submitted by the end of February 2024
- The final prototype demonstration must be ready by the end of April 2024
- Total development costs must not exceed $800 unless additional funding is secured

13 Risks

The following risk census contains identified project risks with estimated exposure probabilities. More accurate analyses and mitigation strategies will be discussed in future development cycles.

Risk description	Probability	Loss (days)	Exposure (days)
Damage to robot components due to improper wiring during assembly	0.05	14	152
Damage to robot components due to exposure to liquids	0.20	14	152
Injury to operators or bystanders from spilled hot liquids	0.03	17	30
Demonstration site is not suitable for robot navigation	0.50	1	1
Delays in development due to students' course loads	0.10	20	2.0
Food service certification delays (if required)	0.20	1	90

Table 2: Overview of highest exposure project risks

14 Documentation & Reporting

14.1 Major Documentation Deliverables

14.1.1 Project Charter

The Project Charter will be updated at the beginning of each sprint to reflect changes made (if any) in team organization and project goals. The latest version will be stored on the team Github repo and will be available to team members at all times. The initial version will be delivered no later than 6 October 2023, and the final version will be delivered no later than one week before the project demonstration in April 2024. Updates to the charter may be delivered as they are pushed or upon request.

14.1.2 System Requirements Specification

The System Requirements Specification will be updated at the beginning of each sprint after the initial delivery to reflect changes made (if any) in product design and derived requirements. The latest version will be stored on the team Github repo and will be available to team members at all times. The initial version will be delivered no later than the end of October 2023, and the final version will be delivered no later than one week before the project demonstration in April 2024. Updates to the System Requirements Specification may be delivered as they are pushed or upon request.

14.1.3 Architectural Design Specification

The Architectural Design Specification will be updated at the beginning of each sprint after the initial delivery to reflect changes made (if any) to the product's architectural design. The latest version will be stored on the team Github repo and will be available to team members at all times. The initial version will be delivered no later than the end of November 2023, and the final version will be delivered no later than one week before the project demonstration in April 2024. Updates to the Architectural Design Specification may be delivered as they are pushed or upon request.

14.1.4 Detailed Design Specification

The Detailed Design Specification will be updated at the beginning of each sprint after the initial delivery to reflect changes made (if any) in team organization and project design. The latest version will be stored on the team Github repo and will be available to team members at all times. The initial version will be delivered no later than the end of March 2024, and the final version will be delivered no later than one week before the project demonstration in April 2024. Updates to the Detailed Design Specificaiton may be delivered as they are pushed or upon request.

14.2 Recurring Sprint Items

14.2.1 Product Backlog

Items will be added to the product backlog by choosing from the remaining items that fulfill the most important product requirements. The team will vote to choose which items from that group are prioritized. The team will use Trello to track product backlog and other Agile metrics.

14.2.2 Sprint Planning

Sprints will be planned during biweekly meetings on Tuesday mornings after the review of the concluding sprint takes place. Each sprint will begin on the Thursday following the sprint planning session. There will be a total of 4 sprints during Fall 2023.

14.2.3 Sprint Goal

Sprint goals will be decided by team vote during sprint planning meetings. As the team is the customer, the customer is technically involved at all steps of the process.

14.2.4 Sprint Backlog

The team will vote to decide which items from the product backlog make their way to the sprint backlog during sprint planning meetings. The backlog will be maintained in Trello.

14.2.5 Task Breakdown

Individual tasks will be voluntarily claimed by team members. Team members may also be asked to claim a task if the other members are unable to claim it. Time spent on tasks will be relayed to the Scrum Master who will then update the relevant charts.

14.2.6 Sprint Burn Down Charts

The Scrum Master will be responsible for generating the burn down chart after the conclusion of each sprint. Team members will relay their expended effort on each claimed task to the Scrum Master during sprint reviews. The burndown chart format will be that provided by Professor Conly. An example is shown below.

14.2.7 Sprint Retrospective

The sprint retrospective will be discussed and filled out on Tuesday mornings during the weekly team meeting. Tasks on the sprint backlog and effort worked on them will be recorded for both the group

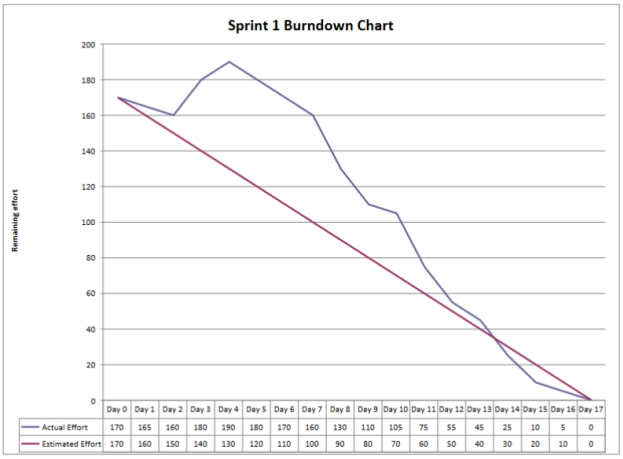


Figure 1: Example sprint burn down chart

and for individuals. The report will be delivered on the first Thursday after the completion of the sprint.

14.2.8 Individual Status Reports

Team members will claim tasks and report expended effort as described above. Team members will report problems encountered and new ideas during sprint reviews and sprint planning meetings. Problems may be reported immediately on the team Discord if the situation requires it (as determined by the team members' judgement).

14.2.9 Engineering Notebooks

The team will not keep an engineering notebook.

14.3 Closeout Materials

14.3.1 System Prototype

The final system prototype will include the MechaMocha robot and all associated charging, control, and reporting hardware and software.

The demonstration will consist of operation of the product to serve coffee or a substitute beverage to team members seated at a table in the demonstration environment. The demonstration will occur at the end of April 2024.

14.3.2 Project Poster

The project poster will be a tri-fold cardboard poster with design details and images from development and testing. It will be delivered during the product demonstration.

14.3.3 Web Page

The project web page will include several pictures of the product in development and during testing close to demonstration. It will become accessible to the public and be provided at closeout.

14.3.4 Demo Video

The demo video will discuss a high-level overview of the product's requirements and design features followed by a demonstration of the product working in the test environment. The video will be between five and ten minutes long, and may include bloopers at the end (subject to team decision).

14.3.5 Source Code

Source code will be maintained on Github, with Git being the underlying version control system. It will not be provided to observers of the project demonstration, though it may be released after the demonstration under GNU or GPL (subject to team decision).

14.3.6 Source Code Documentation

Sections of the product documentation will be assigned as individual tasks to the team members who contributed to the relevant portions of source code. The documentation will be completed no later than two weeks before product demonstration in April 2024, and will be delivered as a PDF.

As of Oct. 6th, 2023, no formal source code documentation standard has been specified.

14.3.7 Hardware Schematics

High-level wiring and physical diagrams of the product will be delivered along with full parts and software lists. Additional diagrams of components will be delivered if detailed information cannot be included on higer-level diagrams.

14.3.8 CAD files

Documentation will be delivered for any mechanical parts developed by the team. As the exact specifications of the product have not been realized yet, no software for 3D printing or CAD has been chosen yet.

14.3.9 Installation Scripts

Controlling software will be provided as a standalone set of files that may be used and deployed by the customer as required.

As the software to control MechaMocha is useless without the robot itself, no form of supervision or SAAS oversight is necessary, though such features could be added in the future to create a continued revenue stream.

14.3.10 User Manual

The end user will need a simple digital manual to use the product. A more detailed manual and redacted copies of the product documentation would be necessary for the end user to carry out maintenance of the product.

REFERENCES

[1] S. Pastis, "Meet new york's robot barista," *Fortune*, June 2023.

[2] L. Fortney, "A dystopian coffee shop run by a robot barista arrives in brooklyn," *Eater NY*, May 2023.

[3] T. Tanksley, "The kardashians hired our robot bartender. here's how it went," *Richtech Robotics Blog*, Sept 2023.

[4] T. Soper, "Robotic coffee barista maker led by ex-aws engineer raises $8.3m to open more retail locations," *GeekWire*, Sept 2022.

[5] M. R. Management, "Service robots solve everyday restaurant problems: Modern restaurant management: The business of eating & restaurant management news," *Modern Restaurant Management*, Jan 2023.