

LazyBots

McMASTER UNIVERSITY

System Requirements

SE 4G06 & TRON 4TB6

GROUP 9

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1 Revisions

Table 1: LazyBots Revision Table

Date	Revision Number	Authors	Comments
October 6 th , 2017	Revision 0	Karim Guirguis David Hemms Marko Laban Curtis Milo Keyur Patel Alexandra Rahman	N/A

2 Project Drivers

2.1 The Purpose of the Project

The purpose of this project will be to create an autonomous robot that will navigate to and serve the requested drink to the user who requests a drink. Currently in an office setting, workers must leave their offices to get their own drinks. Also, in restaurants, drinks are served by waiters and waitresses, which hinders them from doing other work at that time. Alfred will be designed to make the serving drinks autonomous.

Alfred will allow users to request drinks. These requests will form a queue which Alfred will serve in order using a FIFO protocol. Alfred will go to the table of each user and pour the drinks ordered from that table. Alfred will also have an administrator user which will be able to call Alfred back and override any action that is being taken at the time.

The following document will outline the functional and nonfunctional requirements of Alfred. Other topics that will be covered pertaining to Alfred will include: Scope, Project Constraints, Likely Changes and Project Issues.

2.2 Scope

The system implemented is one that is meant to automate the dispensing of beverages to customers within a restaurant at the respected customer's table. The customer will be able to order a drink from their table which will be followed by Alfred arriving at their table and dispensing the requested drinks. The staff will be able to request Alfred to come back for charging and refilling when desired.

2.3 The Client, the Customer, and Other Stakeholders

2.3.1 Client and Customer

- Restaurant Owners
- Restaurant Staff
- Restaurant Clients
- People who are working in a office environment

2.3.2 Stakeholders

Include Stakeholders

- GM, Project Proposers
- Dr. Alan Wassyng, the Project Supervisor
- Stephen Wynn-Williams and Bennett Mackenzie , The Teaching Assistants

2.4 Users of the Product

This product will be used in a restaurant setting, and the users can be divided into two groups. The first group of users will be the customers of the restaurant, who will be placing drink orders and will be served by the robot. The other group of users will be the restaurant staff, who will ensure that the robot is operating properly and keep the fluid levels topped up.

3 Project Constraints

3.1 Mandated Constraints

The following is a list of constraints that will be followed during the design of this system.

MC1	The cost of the project must not exceed \$750 dollars.
Rationale	The project must be economically feasible and cannot be an off-the-shelf solution.

MC2	Weight must not exceed what could the motor would be able to move, given torque limitations of motor.
Rationale	Robot must be able to move with all drink containers filled.

MC3	Project must be finished within the course of the academic year.
Rationale	Must submit finished project by end of academic year as per project requirements.

MC4	Workload must be achievable by 6 people (size of group) in given allotted time.
Rationale	Must be physically possible given allotted manpower and time.

3.2 Naming Conventions and Definitions

3.2.1 Naming Conventions

Note: The following naming conventions apply to this document specifically.

R#	Robot Name
Alfred#	The name of the robot that will deliver drinks
T#	Table Order Identification Number
Tid#	Mandated project constraints identification and number
G#	Graphing notation
N#	a node within a graph representing a table or any other point of interest.
G#	a graph representing the tables as well as the distance from the current table.

3.2.2 Constants

1. **Steps/Revolution** - The number of steps within a revolution of the stepper motor
2. **Pump Flow rate** - The amount of liquid that will be pumped at a specific voltage

3.2.3 Monitored and Controlled Variables

The following is a list of variables that will be monitored.

- Speed of the wheels (rad/s)
- Weight of the storage device (Kg)
- If the cup has been taken (boolean)
- Distance of any obstacles (m)
- Voltage levels of batteries (V)

The following is a list of variables that will be controlled

- Speed of the motor. (rad/s)
- Voltage going to the liquid pumps. (V)
- Signal of drink that it is ready to be picked up (boolean)
- Error codes sent (unsigned byte)

1

3.3 Relevant Facts and Assumptions

3.3.1 Relevant Facts

- A standard cup size contains 12 ounces of fluid.
- All food or drink should not be served below the height of a table.
- Food Safety and Industry standards state that drinks should be kept at a temperature below 4 degrees Celsius.

3.3.2 Assumptions

Alfred assumptions is tables below.

A1	The environment will only be comprised of a one story building with no steps.
Rationale	Different environment elevations are beyond the scope of the project.

A2	The width of the walkways will be wide enough to accommodate all people.
Rationale	If a table is not accessible to a human, it will not be accessible for Alfred.

A3	Orders will be placed via an Android or iOS application.
Rationale	Eliminate the need for human interactions, making Alfred completely autonomous.

A4	The height of a table will not exceed 30".
Rationale	This will help simplify the scope of the project and reduce the amount of drink waste. (accidents)

A5	The serving size of a medium sized cup will not vary largely in terms of ounces.
Rationale	The standard ounces in a cup will be restricted to 12oz. to accommodate as many users as possible and to limit the scope.

4 Context Diagrams

Insert images of context diagrams

5 Functional Requirements

Intro sentence

5.1 Alfred Functional Requirements

?1	Alfred shall be able to determine the desired drinks for a table within the restaurant
Rationale	It is essential for Alfred to be able receive the order of the drinks to be able to pour drinks for the customers

?2	Alfred shall be able to identify the table that a specific drink order belongs to.
Rationale	This is so that Alfred will be able to able to pour the drinks to the correct tables

?3	Alfred shall be able to navigate to the table that corresponds to a specific drink order.
Rationale	This allows Alfred to be able to move without the help from any person.

?4	Alfred shall be able to pour the correct drinks corresponding to the specific tables order.
Rationale	This is that Alfred will be able to pour the drinks for the customers without the need for any human interference.

?5	Alfred shall be able to pour the correct amount for the drink based on the size of the cup.
Rationale	This is that Alfred will be able to pour correct amount of liquid for the user so it will not be under or over filled.

?6	Alfred shall be able to determine when liquids within Alfred's Storage are not cold enough.
Rationale	In order to ensure that the drinks that will be served will meet FDA food regulations.

?7	Alfred shall be able to notify the staff that that the liquids within Alfred's Storage are not cold enough
Rationale	So that the staff will be able to make the appropriate action to cool the drinks down.

?8	Alfred shall be able to determine that any of the liquids within Alfred's Storage are not at sufficient level to be able to pour a cup of the specific beverage.
Rationale	This is so that Alfred will be able to know when it will need to be refilled.

?9	Alfred shall be able to notify the staff that that any of the liquids within Alfred's Storage are not at sufficient level to be able to pour a cup of the specific beverage.
Rationale	This is so that Alfred will be able to receive aid from the staff so that it can continue to fulfill drink orders.

?10	Alfred shall be able to stop for when an obstacle is in the way of Alfred
Rationale	This is so that Alfred will be able to ensure that the customers will remain safe when around them and that Alfred will not cause property damage.

?11	Alfred Shall be able to determine when an aspect will no longer be functional due to low power.
Rationale	This is so that Alfred will be able to take the appropriate actions so that way if we can ensure that Alfred will return to base before it needs to shut down.

?12	Alfred Shall be able to navigate back to its home base at any given point in time.
Rationale	This is so that it will be able to return if there is any issues with temperature, power and drink levels. It is also so that at the end of the day the staff can request for Alfred to return back to home base

?13	Alfred Shall be able to Indicate to the user when the drinks is ready for the user.
Rationale	This is so that the user will know when the drink is finished and is ready.

?14	Alfred Shall be complete orders in the order that they were received in.
Rationale	This is so that fairness is consistent for the user.

5.2 Table Ordering Application Functional Requirements

?15	The ordering application shall allow the user to be able to place an order for Alfred.
Rationale	This is so that Alfred will be able to bring the beverages of the table.

?16	The ordering application shall be able to transfer the order to the list of Alfred's drink orders.
Rationale	This is so that Alfred will be able to receive the specific order from the application.

5.3 Administrator Application Functional Requirements

?17	The Administrator Application shall allow the user to create a map of the restaurant for Alfred.
Rationale	This is so that Alfred will be successfully be able navigate to the location of specific tables.

?18	The Administrator Application shall allow the user to insert tables, obstacles and paths to travel.
Rationale	This is so that Alfred will be successfully be able navigate to the location of specific tables.

?19	The Administrator Application shall allow the user to view all of the orders that were created by the ordering application.
Rationale	This is so that the restaurant shall be able to make bills based on this information

?20	The Administrator Application shall be able to view the status of Alfred.
Rationale	This is so that the restaurant staff shall be able to ensure that Alfred will remain functional

6 Functional Decomposition Diagrams

Insert Functional Decomposition Diagrams!

7 Functional Requirements Likelihood of Change

7.1 Subsection 1

Requirement	Likelihood of Change	Rationale	Ways to Change
?1	Likelihood	Rationale	Change
?2	Likelihood	Rationale	Change
?3	Likelihood	Rationale	Change
?4	Likelihood	Rationale	Change

7.2 Subsection 2

Requirement	Likelihood of Change	Rationale	Ways to Change
??1	Likelihood	Rationale	Change
??2	Likelihood	Rationale	Change
??3	Likelihood	Rationale	Change
??4	Likelihood	Rationale	Change

7.3 Subsection 3

Requirement	Likelihood of Change	Rationale	Ways to Change
??1	Likelihood	Rationale	Change
??2	Likelihood	Rationale	Change
??3	Likelihood	Rationale	Change
??4	Likelihood	Rationale	Change

8 Nonfunctional Requirements

8.1 Look and Feel Requirements

8.1.1 Appearance Requirements

- (i) Alfred shall have any functional equipment hidden within its containment unit unless the user needs to interact with it.
- (ii) Alfred shall not have any exposed electronic wiring.

- (iii) Alfred shall be at the appropriate table height.

8.1.2 Style Requirements

- (i) Alfred shall be painted friendly colours
- (ii) The drink ordering application shall not be visually cluttered.

8.2 Usability and Humanity Requirements

8.2.1 Ease of Use Requirements

?1	Alfred shall make it user to grab the users drink within 10 seconds.
Rationale	This is about the amount of time to determine that the cup is ready to grab it.

?2	Alfred shall make it so the user to be able to tell when a drink is done within one second.
Rationale	This is so that the user will not have to wait a large amount of time.

8.2.2 Personalization and Internationalization Requirements

- (i) Text

8.2.3 Learning Requirements

?1	The ordering application shall make it that the user can learn to order a drink within 2 minutes of use.
Rationale	This is about the amount of time the user would take to explain there order to the restaurant staff.

8.2.4 Understandability and Politeness Requirements

?1	Alfred shall not say anything to offend the user .
Rationale	To ensure that the user will not be offended.

8.2.5 Accessibility Requirements

- (i) Text

8.3 Performance Requirements

?1	Alfred shall be able to determine the shortest path within 30 seconds.
Rationale	The approximate amount of time to determine the shortest amount of time to a table, so that the user will not have to wait a long time.

8.3.1 Speed Requirements

?1	Alfred shall be able to pour a drink within 30 seconds.
Rationale	Approximate time for a person to pour a drink
?2	Alfred shall be able to move at human speeds.
Rationale	So the user will not be waiting longer then the normal system, as well as ensuring that the robot will not be moving to fast for a restaurant environment.
?3	Alfred shall be able to receive an order within 30 seconds.
Rationale	So that the speed of communication will not limit when the user will receive there drink.
?4	The ordering application be able to send an order to the administrative program within 30 seconds.
Rationale	So that the speed of communication will not limit when the user will receive there drink.

8.3.2 Safety-Critical Requirements

?1	Alfred shall be able to determine when an obstacle is one meter in front of it in order to stop it.
Rationale	The approximate amount of room to be able to decelerate properly
?2	Alfred shall not pour a drink for the user if it is not at a safe temperature.
Rationale	To ensure that the user will not drink any liquid that is not safe to drink
?3	Alfred shall not cause property damage from movement.
Rationale	To ensure that no damage will be done to the restaurant

8.3.3 Precision Requirements

?1	Alfred shall be able to fill the cup from 75-85 percent full.
Rationale	The approximate amount so that the user will not be upset receiving too little as well as not overflowing the cup.
?2	Alfred shall be able to get within 1 foot of any programmed node.
Rationale	To allow the robot to get close enough for the guest to grab the drink
?3	The system shall not distort the users order at any point if the drink order will not be able to be translated back.
Rationale	To ensure that the user will get the drink they ordered

8.3.4 Reliability or Availability Requirements

?1	Alfred shall not allow drinks to leak.
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Rationale	So that if the robot is tipped over, it will not affect any electronics within the robot
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8.3.5 Robustness or Fault-Tolerance Requirements

(i) Text

8.3.6 Capacity Requirements

?1	Alfred shall be able to store 2 Litres of any non perishable drink.
Rationale	So that the robot will not have to constantly return back to base, but will be able to be mobile

8.3.7 Scalability or Extensibility Requirements

?1	This system shall only require one work week to implement within any establishment.
Rationale	So that the system will be able to be introduced into a restaurant without disturbing workflow for a long period of time

8.3.8 Longevity Requirements

?1	Alfred shall be able to keep drinks cold for a typical 8 hour work shift.
Rationale	This is so that the robot will not have to return back to the kitchen too much for warm drinks

8.4 Operational and Environmental Requirements

8.4.1 Expected Physical Environment

(i) Text

8.4.2 Requirements for Interacting with Adjacent Systems

(i) Text

8.5 Maintainability and Support Requirements

8.5.1 Maintenance Requirements

?1	Alfred shall be able to determine if it will not be able to function.
Rationale	So that it will be able to report any errors properly
?2	Alfred shall be able to determine why it will not be able to function

Rationale	So that it will be able to report any errors properly
?3	Alfred shall have it so its easy for components for be removed
Rationale	So that components will be able to be easily swapped out if they are not functional.

8.5.2 Supportability Requirements

?1	The administrator system shall have help documentation for the user.
Rationale	So that the user will be able to read about how to use the system if they choose to.
?2	The order system shall have help documentation for the user.
Rationale	So that the user will be able to read about how to use the system if they choose to.

8.5.3 Adaptability Requirements

(i) Text

8.6 Security Requirements

8.6.1 Access Requirements

?1	The ordering system shall allow the user to see what they have ordered.
Rationale	So that the user can verify that the order is correct

8.6.2 Integrity Requirements

?1	The system shall use encryption that will not loss information.
Rationale	So that no drink order or any information is lost during communication

8.6.3 Privacy Requirements

?1	The ordering system shall not be able to show any information about other peoples drink orders.
Rationale	So that information is kept private
?2	The system shall use secure protocols for any communication.
Rationale	So that information is kept private

8.6.4 Audit Requirements

(i) Text

8.6.5 Immunity Requirements

?1	Alfred shall have a chamber to prevent drinks from warming up.
Rationale	So that the robot will have to go to the kitchen less times within a night.

8.7 Cultural and Political Requirements

8.7.1 Cultural Requirements

- (i) Text

8.7.2 Political Requirements

- (i) Text

8.8 Legal Requirements

8.8.1 Compliance Requirements

?1	Alfred Shall follow food regulations.
Rationale	So that the restaurant will ensure public health will not be in danger by using this system.
?2	Alfred shall not preform any discriminatory actions to the user.
Rationale	To ensure that everyone will feel welcome to use Alfred
?3	Alfred shall not server any alcoholic beverages or prohibited substances.
Rationale	To ensure that all ages can be served by Alfred.

8.8.2 Standards Requirements

?1	Alfred shall follow the law of robotics.
Rationale	To ensure that users are safe when using Alfred.

9 Project Issues

9.1 Open Issues

- (i) Weight of the containers requires a lot of torque to get the robot to move at the desired speed.
- (ii) Rotation of the robot causes the liquids to sway inside the containers causing momentum opposite to the desired direction of motion.
- (iii) Smooth acceleration and deceleration to avoid liquid spills due to rapid speed increase or decrease.
- (iv) Pumping mechanism running using an Arduino while drive-train is a raspberry pi. Low Latency communication between the two boards is vital.

- (v) Reporting to server in the case of sensor/board failure

9.2 Off-the-Shelf Solutions

9.2.1 Ready-Made Products

- (i) Bar2D2 - a radio-controlled, mobile bar that features a motorized beer elevator, motorized ice/mixer drawer, six-bottle shot dispenser, and sound activated neon lighting.
- (ii) Laskmi-Do Corporation Table Robot - a robot two wheeled robot that delivers drinks.

9.2.2 Reusable Components

- (i) Text

9.2.3 Products that can be Copied

- (i) Text

9.3 Risks

- (i) Components break over time and due to accidents
- (ii) Alfred gets stuck behind an obstacle (if someone places chair in front as opposed to someone walking by)
- (iii) Alfred spills drinks or has drinks spilled on it
- (iv) User error during interaction with Alfred
- (v) User error during interaction with the client side application
- (vi) Alfred harms someone
- (vii) Alfred is not cleaned properly
- (viii) There is a major roadblock in development/construction

9.4 Costs

The budget for the all components of the robot must not exceed \$750. A breakdown of the individual part costs is as follows: **Make a long table for this...**

- A: Raspberry Pi: \$50
- B: Arduino: \$10
- C: Mosfets: \$10
- D: Storage Containers: \$25
- E: Piping: \$20
- F: Pumps: \$30
- G: Motors: \$60
- H: Wheels: \$40
- I: LEDs: \$5

J: Wires: \$10

K: Structural Materials (wood, metal ect): \$100

L: Motor Drivers: \$40

M: Battery Power: \$50

Total Cost : \$450.00

9.5 Waiting Room

- (i) Having Alfred being able to recognize objects using image recognition
- (ii) Developing a more robust advanced administrative application to include billing and table availability