## Title
SnackBot



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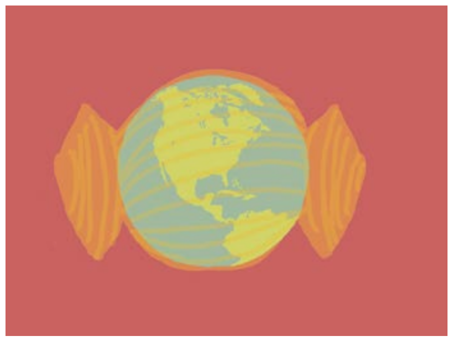
# 2021 MAE Design Project - SnackBot



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# Table of Contents

# Design Prompt

With the sudden rise in COVID cases, there has been a complete halt in people going out to movie theatres to enjoy movies. Not only has this decreased the business for the film industry but also taken a toll on normalizing "sanitation and safety" while being present at a public place. Hence, the MAE committee's goal for this year's conference is to design a robot that not only moves around the movie theatre distributing snacks and drinks ordered by the customers but also provides them with sanitizer everytime it delivers the food. Moreover, the overall goal of the project is to build a movie theatre that is COVID-free while keeping in mind the safety and satisfaction of the customers!

# Overview

Movie theaters are known to be jam packed with people, this tightly-packed crowd creates a gateway for Covid and other transmissible diseases to be easily spread in a susceptible population. Without innovating how theaters operate, they are at risk of closing down for good. Our design of the Snackbot heavily revolves around the main concern of staying contactless and sanitary during operation. The Snackbot will make theaters and people a lot safer by integrating sanitation stations into the Snackbot and minimizing the risk of product contamination.

Our Snackbot will implement an app onto the customer's phone, where they will order their food and beverages. Once the order is placed, an employee will safely put together and place the order into the corresponding pod. In the pod, there will be a UVC light, essentially sanitizing the contents and interior of the Snackbot. The Snackbot will then make its way from the front counter to the corresponding aisle where the customer is located. The customer will walk to the edge of where their row of seats are located, the customer then pulls up a barcode on their phone through the app, once the Snackbot successfully scans the barcode, an elevator inside the robot will move to the corresponding pod where the customer's order is located. The order will then be moved onto the elevator platform along a simple conveyor belt. As the Snackbot is retrieving the order, a friendly reminder to sanitize their hands will be sent via a push notification on the app. Finally, the elevator will push the order up, where a door will swing open and the customer may retrieve their order. By having the customer pick up the order at the top of the Snackbot, instead of reaching into the interior of the robot, customer's contact with the robot will be greatly minimized.

During the four days of designing the Snackbot, time constraints were a problem since we all had different schedules which made finding decent times for us all to meet difficult. When we were coming up with ideas for the project, we were having a tough time bouncing around different ideas and deciding which was the most optimal. Another problem we unfortunately faced was losing two of our team members in the process of designing the Snackbot due to schedule conflicts. Not having the ability to meet with the team face-to-face was an additional obstacle we had to overcome. However, despite the fact that we could not really be working “together”, we communicated well enough with each other to all stay on the same page. One of the more important lessons learned during this project was proper and efficient communication in a virtual environment. Through constant communication with each other, we were able to design and complete the Snackbot in a timely manner.

Some supporting facts and market differentiators of the Snacky McSnack Face Snackbot can readily be seen in the vast array of technologies implemented in the design of the Snackbot. These technologies ensure safety, reliability and optimal customer satisfaction. Some of these technologies include; UVC lighting on the interior of the robot to maintain a sanitary environment during every stage of operation, a motion-activated hand sanitizing station that is readily accessible on the side of the snackbot next to the barcode scanner, and a convenient elevator that lifts orders to the top of the robot for easy retrieval while nearly eliminating customer contact with the snackbot. Additionally, two electric driven wheels provide optimal travel efficiency, stability and great turning capabilities. A radar sensor array integrated flush into the exterior of the Snackbot enables object detection and collision avoidance up to five feet away. A Raspberry Pi 4 Model B acts as the brains of the Snackbot, enabling most of the Snackbot functionality; this includes, slowing or stopping the Snackbot if an object is detected in the robot’s path, storing the queue in which trays are loaded into the Snackbot for customer retrieval upon destination, a barcode scanner that enables the customer to easily verify their order and enable the Snackbot to retrieve their order without having to ever physically touch the robot, path planning, and correction guided by a closed-loop feedback control algorithm.

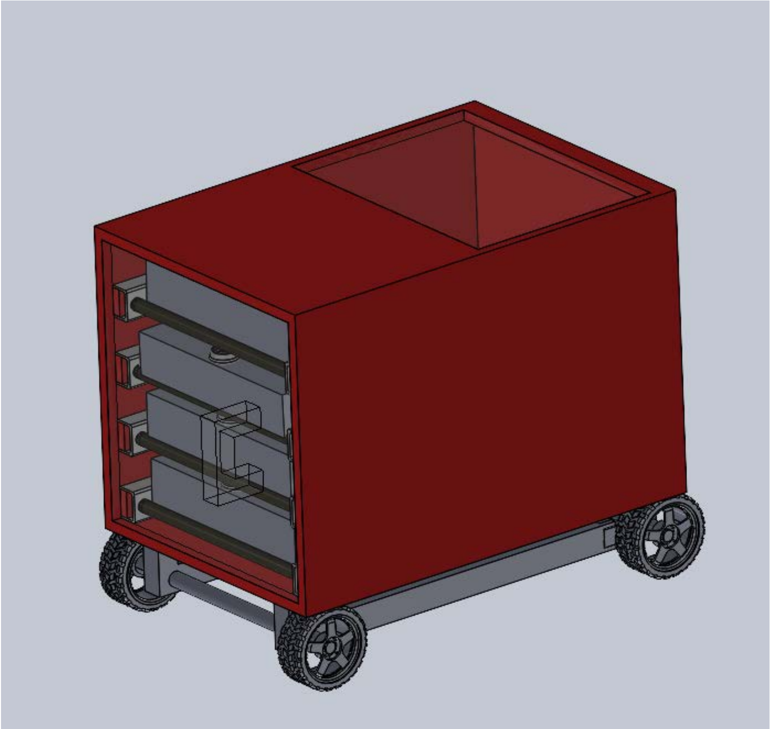
# Goal

1. Create an efficient Snackbot that provides contactless, safe services for customers.
2. Help revamp movie theaters and incentivize people to start going back comfortably.
3. Reduce the spread of transmissible diseases as much as possible.
4. Create an optimal path to and from a customer's location, avoiding obstacles along the way.

# Objectives

1. Keep the bot under the maximum height limit of 36 inches in order for it to not interfere with the movie theater screen.
2. Reduce the footprint of the robot as much as possible to reduce blocking aisles in case of emergency.
3. Maintain the least amount of contact possible throughout the whole process of ordering and retrieving the order.
4. Create a universal, easy to use system for the customer.
5. Maintain a sanitized Snackbot, both inside and outside.
6. Create the most efficient robot possible while keeping the cost of producing it relatively low.

# Project Outline



The red exterior is our chassis, which homes the grey trays atop conveyor belts. Underneath the chassis, you can spot the steering system consisting of two steering wheels and two free wheels. What is hidden in this illustration is the elevator system that brings trays to the opening at the top of the chassis. On the other side of the chassis, there is a hand sanitizer dispenser and a barcode scanner attached. There is a backdoor to be used by the theater employees to stock the specified orders, and the customer will retrieve their orders from the elevator when the top door opens up once the unique barcode is scanned.

# Design Breakdown

**Justification:**

One decision that we contemplated was a ferris wheel design to bring orders to the top to be retrieved. In the end, however, we decided to go with a conveyor belt and elevator concept instead as it's a more simple, straightforward design that achieves the same goal.

We also decided to have the popcorn go in low-profile boxes rather than buckets to accommodate four levels of food, as opposed to using tall popcorn buckets.

**Calculations:**

Calculations behind meeting height requirement:

- Soda Cans
  - 24 oz Mega Monster Energy Drink [1]
    - Approximately 8.46 x 2.87 x 2.87 inches
    - **Note: Too tall, not offered
  - 12 oz Can of Coke [2]
    - Height: 4.83 inches
    - Top Diameter: 2.13 inches in diameter at the narrowed top
    - Outer Diameter: 2.60 inches
- Candy
  - 3.1 oz M&M's Milk Chocolate Candy Theater Box [3]
    - Dimensions: 0.71 x 6.06 x 2.52 inches
- Popcorn
  - 130 oz Bucket [4]
    - Height: 8.25 inches + 1.5 inches of popcorn
    - Bottom Diameter: 5.75 inches
    - Top Diameter: 7.625 inches
    - **Note: too tall, low box replacement offered instead
- Chassis/Frame
  - Wheels [5]
    - Height: 7.5 inches
  - Food slots
    - Height: 4*4.83 (four levels of trays) + 7.5 = 26.82 inches

Accounting for the above dimensions, we have approximately 10 inches remaining for conveyor belts, clearance, and chassis thickness. We deemed that remaining space reasonable and ended up with a final product height of 35.92 inches.

**Technologies:**

Raspberry Pi 4 - Model B: operates robot functions [6]
UVC lights: added feature to disinfect interior of robot [7]
QR Code Scanner: scans QR codes from customer/employees [8]
Batteries: 48 kV batteries to power robot [9]
Aluminum Chassis: provides structure
Conveyor Belts: move trays to elevator once tray is summoned by customer [10]
Elevator: brings order to top surface of robot [11]
Steering Wheels: motor controlled wheels [12]
Free Wheels: motorless wheels, same dimensions as steering wheels
Collision Avoidance: parking sensor array to prevent collisions [13]
Robot Frame: shell and interior mounts

**Features:**

UVC lights: added feature to disinfect interior of robot
QR code scanner: allows for customer to obtain correct order from robot in contactless fashion
Collision Avoidance: parking sensor array to prevent collisions
Conveyor Belts: bring trays to the elevator seamlessly.
Elevator: raises orders to top of chassis so customer can grab without touching robot

# Bill of Materials

| Item | Description | Unit Price | Quantity | Total Price |
|---|---|---|---|---|
| *Steering wheels* | *Electric motor integrated wheels* | *75.00* | *2* | *150.00* |
| *Free wheels* | *Same as steering, minus electric motors* | *25.00* | *2* | *50.00* |
| *Batteries* | *48kV, 1kW capacity* | *44.50* | *4* | *177.99* |
| *Raspberry Pi 4 - Model B* | *Control module that operates most robot functions.* | *35.00* | *1* | *35.00* |
| *Aluminum chassis* | *Provides structural rigidity for robot* | *80.00* | *1* | *80.00* |
| *Robot Frame* | *Exterior shell + interior mounts for robot* | *160.00* | *1* | *160.00* |
| *Conveyor belts* | *Moves trays from slots onto elevator* | *53.50* | *4* | *214.00* |
| *Elevator* | *Lifts trays to customer for retrieval* | *185.99* | *1* | *185.99* |
| *UVC Lights* | *Disinfecting the interior* | *24.75* | *4* | *99.00* |
| *Cardboard Trays* | *Hold customer meals/orders* | *0.50* | *4* | *2.00* |
| *QR Code Scanner* | *Scans QR codes from customer/employees* | *29.99* | *1* | *29.99* |
| *Collision avoidance* | *Parking sensor array to detect objects in the path of the snackbot.* | *23.99* | *1* | *23.99* |
| Grand Total: | $1,207.96 | | | |

# Conclusion

Our project effectively and reasonably minimizes human contact while satisfying people's need for food and drink during movies. The price of our robot is a mere $1,200 dollars, significantly less than the maximum budget of $10,000. In addition, the app and QR code system makes the process accessible and simple for the customer whilst lessening the need for physical contact. The elevator and conveyor belt system similarly minimize contact between the customer and robot. In addition, the UVC lights add even further protection by sterilizing all surfaces inside the Snackbot. The collision avoidance feature adds to safety while the Snackbot is in motion. Our design is feasible as well as easily manufacturable, utilizing a lot of basic geometry for the chassis, doors, and even the popcorn boxes. The conveyor belt consists of a straightforward cylindrical bar design that is also easily manufactured. This design and assembly process was all done in the span of four days, and if given more time to work on the project, we would have loved to implement improvements and updates to our original design. One main idea that we would like to implement in the future is creating two sides of trays, one for cold foods and one for hot foods. The left side of the robot would basically be a cooler and the right side of the robot would be a heater, with the elevator placed in the middle. Additionally, with more time we would be able to provide the necessary code in order to determine the robot's specific path.

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