ECE 445 Spring 2021

More Than A Chopping Board

Design Document Check

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1. Introduction

Our product, More than a chopping board, helps chefs, amateurs or pros, cook easier and better by giving them a tool to automate cutting vegetables. In restaurants, we see the demand for less pre-handled ingredients to curb the spread of covid. In households, we see the rise of cooking in general and those who want to venture out and create recipes with more ease. With our product, we can allow consumers to cut six types of vegetables in eight different ways by the press of a button. This will allow restaurants to have less direct hand-contact with the ingredients and allow household consumers to easily and safely cut their vegetables for their next meal.

The novelty of our product comes from the fact that there are plenty of vegetable cutters, mandolin, choppers, yet no one universal product to execute different chopping methods, especially automatically. We also see that the products currently on the market each only cater to only a few vegetables, if not one, per each gadget. We want to combine the functionality of multiple vegetable cutters/handlers in one while giving consumers even more options to chop them up into different styles.

2. High-level Requirements

- Our assembly must be able to recognize that a vegetable has been inserted. Once that is put into the chopping area, our system should be able to detect which cuts are suitable for the inserted vegetable. Our system must offer among **four** different chopping styles along with specific recommendations for the detected vegetable: large dice, medium dice, small dice, and Batonnet (Tan, 2019).
- The dimensions of the chopped vegetables should achieve **75%** accuracy according to the dimensions defined in French cooking (Tan, 2019).
- Our system should be able to finish the entire process from when the vegetable has been placed on the chopping board to when the chopping is done in **6 minutes**. In calculating this value, we have assumed a runtime of 0.5 minutes for our vegetable detection program, 0.5 minutes for the user to confirm the style of chopping, and 4 minutes for chopping the vegetable under ideal conditions, give and take 1 minute for user trial.

3. Block Diagram

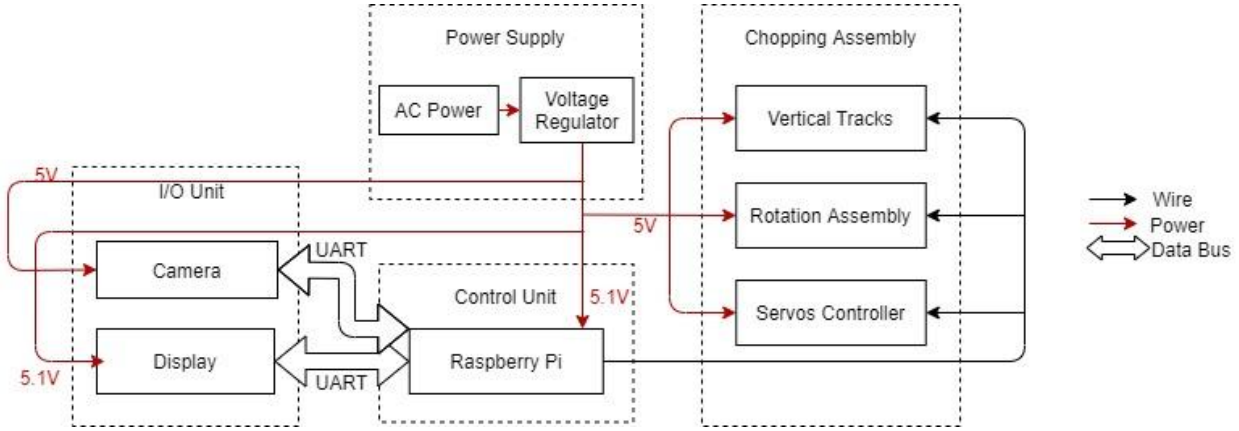

Figure 1. Block diagram for More Than a Chopping Board

4. Physical Design

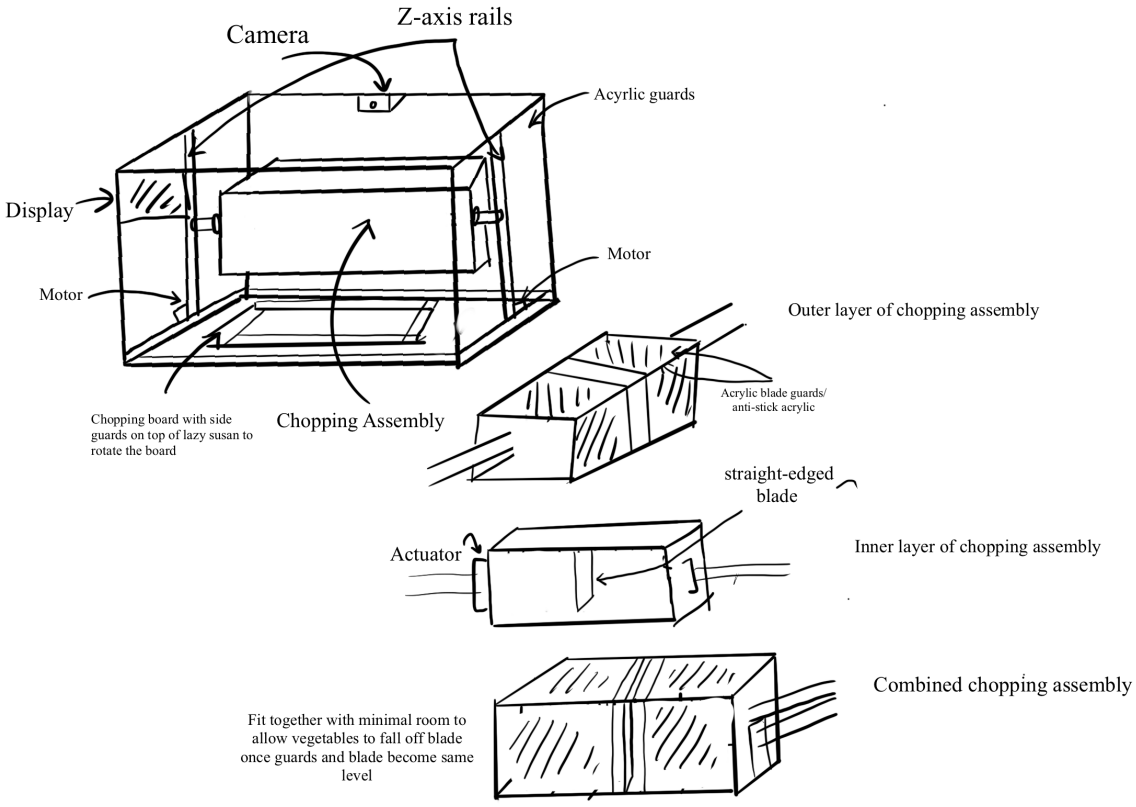

Figure 2. Physical design sketch for More Than a Chopping Board

5. Requirements and Verification Table

5.1. Power Supply

Requirement	Verification
1. Must supply at least 5.1V at 3A to the control unit 2. Must supply 12V at up to 3A to the linear actuator. 3. Must supply 5V at 5.1A to the rest of the chopping assembly. 4. Must supply 5V at 2A to camera and 5.1V at 2.5A to display in the I/O unit	1. Connect the power supply to an AC outlet subsequently testing the different outputs with a digital multimeter

5.2. Control Unit

Requirement	Verification
1. Must detect vegetable inserted 2. Send commands to chop vegetable number of times it needs for the specific cutting mode	1. Insert vegetable in and read for signal to be detected as inserted 2. After pressing confirm to cut, the z-axis rail attached to chopping assembly should start moving

5.3. Chopping Assembly

Requirement	Verification
1. Must be able to exert a maximum of 300N of force onto the vegetable 2. Not draw more than 5V at 3A in total 3. Vegetables cut within 4 minutes with 75% accuracy	1. Placing a weighing scale under the assembly without the blade to measure the force exerted. 2. Use a multimeter to measure the power draw of the assembly 3. Measure the chopped vegetables to see if they are the right size.

5.4. I/O Unit

Requirement	Verification
1. Must be able to send a visual feed of chopping region to the Raspberry Pi 2. Must display option to select cutting style and view recommended cutting style 3. Must allow users to confirm selected vegetable and cutting style to start 4. Must allow users to do a full stop of the chopping process	1. Connect the raspberry pi to a display and show visual feed from the camera. 2. Be able to view recommended cutting style and toggle between different cutting styles 3. View an additional confirm button before starting the cutting process on the LED display 4. When in operation, an option to halt the process appears on LED display and toggling halts the process.

6. Schematics

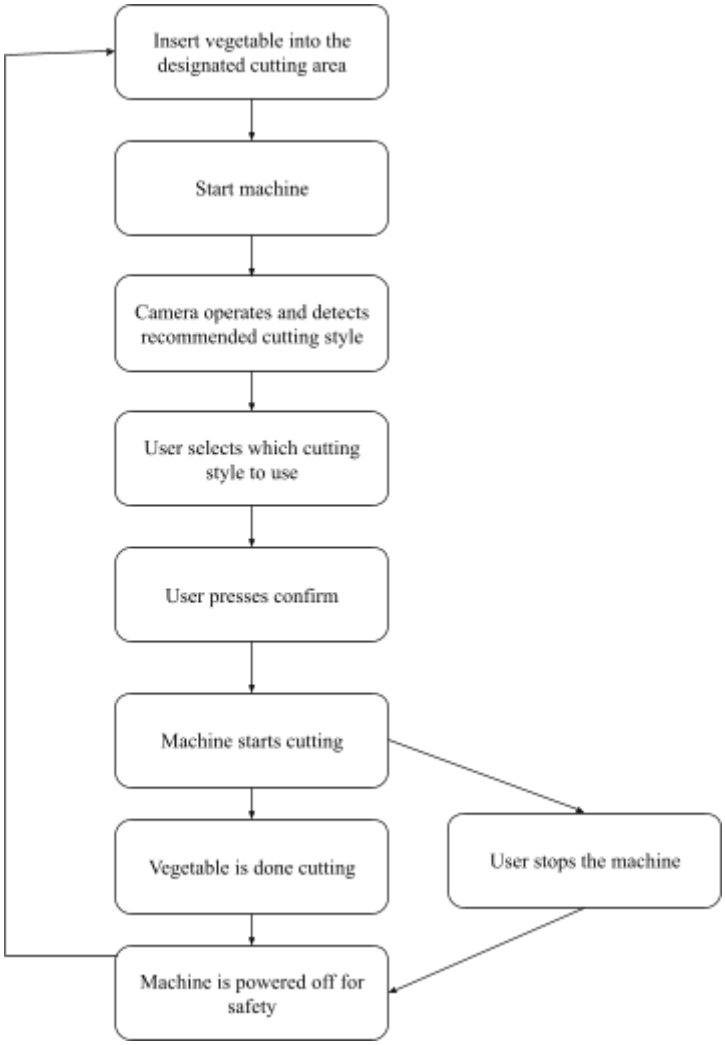

Figure 3. Flowchart for operation

7. Tolerance Analysis

The chopping assembly and its precision is an integral part of the success of this project in ensuring that regular consumers can get finely chopped precise vegetables. In addition, the time taken to complete this task should also be within constraints in order to actually drive value for the users of the product. Our tolerance analysis on this assembly thus hinges on two aspects, the precision and the speed of our chopping assembly.

Precision:

The Nema 17 stepper motor has a 1.8 degree step angle which means the stepper takes $\frac{360}{1.8} = 200$ steps per revolution. The finest cut in our high level requirements is the small dice cut which requires a size of 1/4inches (6.35mm) assuming our chopping assembly is 8inches long, it'll take 32 steps of 1/4inch to cover the length of the assembly. With 1.8 degrees corresponding to one step on the stepper motor the belt drive would have to be designed to operate in a way that each step in the x/y axis of the chopping board, would take 5 steps of the step motor, i.e 9 degrees of rotation. This way the stepper motor can cover $\frac{360}{9} \times 0.25 = 10 inches$ in a full rotation which would be more than enough to cover the length/width of the chopping board and give us fine control over the size of our vegetables. By using 5 rotations per step we will also be able to operate the assembly a little faster thus saving the consumer a lot of time.

Time:

The linear actuator selected for the project has a 2inch stroke length with a travel speed of 12mm/s thus the linear actuator would take a total of 4.23s per extension, since the motion required has to go to ways, up and down the total time per stroke would be 2*4.23 ≃8.5s giving us a total of 28 strokes in the 240s time limit allotted to the chopping assembly. This is approximately close to the number of rotation steps (32) needed to cover the 8inch chopping board in 1/4inch steps and thus ensures we can actually cut the largest possible vegetable that can be fit onto the board as finely as possible.

8. Cost Analysis

The group comprises 2 Computer Engineering and 1 Electrical Engineering major. The average salary for a UIUC Computer Engineering graduate is $106,551 which corresponds to $51.23 hourly. The average salary for an Electrical Engineering graduate is $79,714 which corresponds to $38.32hourly. Thus, assuming 15 hours of work per week for 12 weeks this semester, the total wages for the development of this prototype would be $51.23 * 2 * 15 * 12 + 38.32 * 15 * 12 = \$25,340$ in addition the approximate costs of the parts is as follows:

1. Linear Actuator = $43
2. Nema 17 stepper motor (3 pack) = $24
3. Raspberry pi 4 (4gb) = $61.5

4. Raspberry pi camera module = $10

Total cost = $138.5

9. Ethics and Safety

Possible safety concerns of this project contain injuries related to sharp objects. In the ACM Code of Ethics 1.2 (ACM Code 2018 Task Force, 1992), we are to “Avoid Harm”. Since we plan on providing blades along with the assembly of our project, we, along with the consumers, have to be extremely careful as they would around any other sharp objects.

Consumers could be harmed in the process of inserting the blade in while the machine is operating, or hurt themselves while in the process of initially inserting the blade assembly to cut their wanted object. We plan to diminish this by making sure the users confirm their choice to chop on the display by an additional button. Along with this, we will provide the packaging of the blade with designated cases for the blade portion of the chopping assembly. This way when the consumer or we want to switch out the style of blade to use, the blades will have a safe spot to return to. Among specific accommodations for the knife, there are few general precautions to take when operating this machine. It should be used only on top of a cutting board that is given on a flat surface. Small children should be kept away from operating this machine. Considering an even better failsafe, we hope to implement an emergency stop if all else fails and if the users assume they will hurt themselves accidentally.

Along with also the issue of safety, this assembly could cause electric shock if mishandled, especially in its intended environment, the kitchen. Since the vegetable inserted should ideally be washed, the product should be able to handle the contact of water between the blade and the vegetable, since the blade and its plastic protector are waterproof. This product should ideally not be submerged under water at any point. The consumers might shock themselves if the device is near water or the consumers have an excessive amount of water on their hands to operate it. We plan on coating the outer and inner portions of the product in waterproofing coating, to make it water-resistant for the occasional contact of water.

Unfortunately, there are ethically gray areas about developing such products. Since we are not able to detect much more than an object inserted, we cannot foresee what sort of objects are going to be cut. For us, we will only be using vegetables described above, but since we do not have control over what gets put into this assembly, we cannot guarantee that it will be a vegetable. This product is only suitable for food use and to avoid ethical breaches, there will be a written warning to insert only food items into the board to urge users to only put in items they deem appropriate.

For the testing of this project, we will be implementing a mode on our cutting manual to only cut once, and halt until a resume button is pressed, and additionally confirmed. In addition, we will

be wearing protective goggles and gloves while testing the blade mechanics. We will abide by the ethics guidelines set by IEEE and ACM to best bring this product into the best light.

Citations

ACM Code 2018 Task Force. 1992. ACM code of ethics and professional conduct. *Communications of the ACM* 35, 5 (1992), 94–99. DOI:http://dx.doi.org/10.1145/129875.129885

Rachel Tan. 2019. Kitchen Language: What Are The Basic Knife Cuts? (January 2019). Retrieved March 1, 2021 from https://guide.michelin.com/en/article/dining-in/kitchen-language-what-are-the-different-knife-cuts