ECE 445 Spring 2021

Project Proposal

More Than A Chopping Board

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1. Introduction

1.1. Objective

With people working from home and just staying indoors in general, cooking has become a lot more prevalent in most households, especially amongst college kids who don't have the capital to eat out every day. An integral, often hated, hazard prone and time consuming part of the cooking process is chopping up the ingredients that need to go in the meal. In the COVID era, even restaurants are in need of a better solution than buying pre-packaged ingredients in hopes of reducing human interaction with those ingredients.

To solve these problems is our proposed solution, "More Than Just a Chopping Board". This solution is presented in a time where there exists no convenient universal automatic tool to help chop while reducing human interaction with the food, reducing knife-related injuries, and lastly, saving effort in trying to cut different ingredients by yourself for the next meal.

1.2. Background

A study done in 2012 [1] found that there were about 1190 cases of knife-related injuries per day, with about 280 cases of it being in the kitchen with lacerations on fingers/hands. One can assume that those were caused by trying to cut things on the cutting board and missing the object, and rather leaving injuries on their hand.

There has been a significant increase of the population staying at home and cooking due to the massive shutdowns of restaurants and health concerns due to the COVID-19 pandemic. 71% of consumers [2] stated that they will continue to cook at home more often even after the pandemic is over.

Along with the more statistical background of the problem at hand, we also have personal relationships with this problem, as university students. Many students are starting to cook by themselves for possibly the first time. This comes with plenty of mistakes and injuries relative to cooking something with minimal cutting or instant food. With our project we hope to minimize the injuries and preparation time that comes with chopping, so that cutting vegetables is not what gets in the way of cooking a meal.

With the consideration of the growing number of individuals cooking as well as the need to have safety precautions of the pandemic in restaurants and such, our solution offers a unique and helpful product to help navigate the kitchen a little more safely and with ease.

1.3. Physical Design

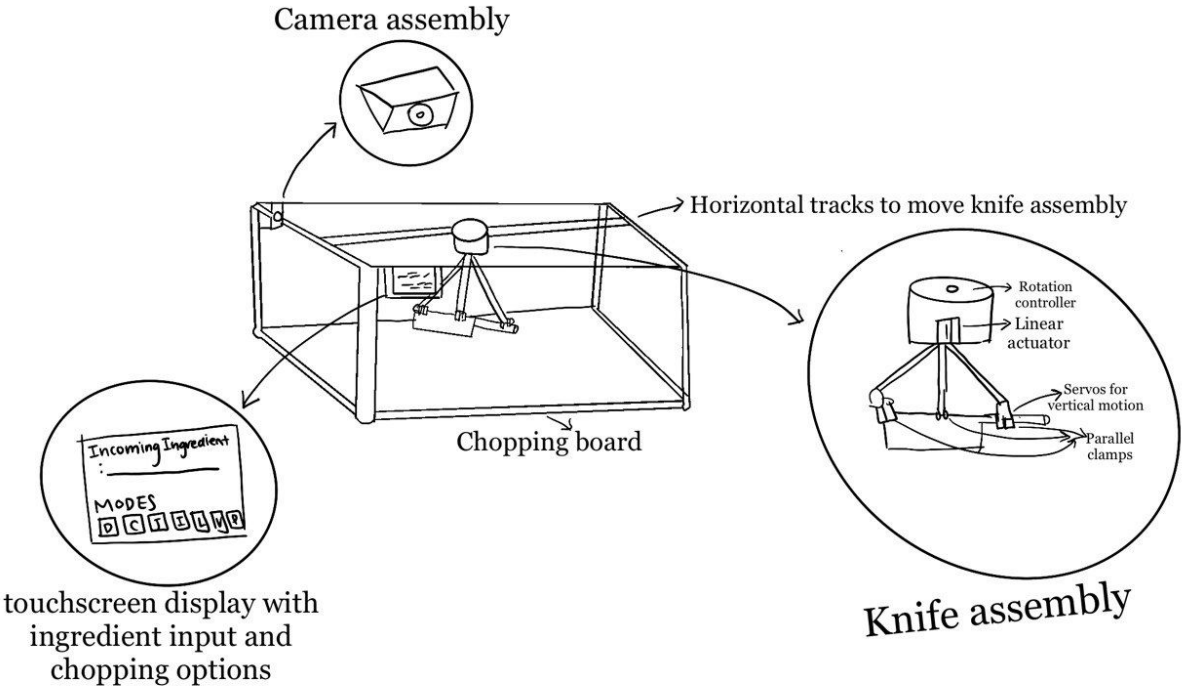

Figure 1. The Proposed Physical Design

1.4. High-level Requirements List

- Our assembly must be able to distinguish between **six** common vegetables: potatoes, tomatoes, onions, bell peppers, lettuce, cucumbers, and cabbage. Once any of the above stated vegetables is placed on the board, our system should be able to detect which of the listed vegetables it is. Our system must offer among **eight** different chopping styles along with specific recommendations for the detected vegetable: large dice, medium dice, small dice, Pont-Neuf, Batonnet, Julienne, Brunoise and Paysanne [3].
- The dimensions of the chopped vegetables should achieve **75%** accuracy according to the dimensions defined in french cooking.
- 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 5 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, 3 minute for chopping the vegetable and an extra minute for any delays on the user's end. Our system should be able to supply at least the following power to the following components:
    - **5.1V** at **3A** to the Raspberry Pi
    - **5V** to the chopping assembly
    - **5V** at **2A** to the camera
    - **5.1V** at **2.5A** to the display unit

2. Design

2.1. Block Diagram

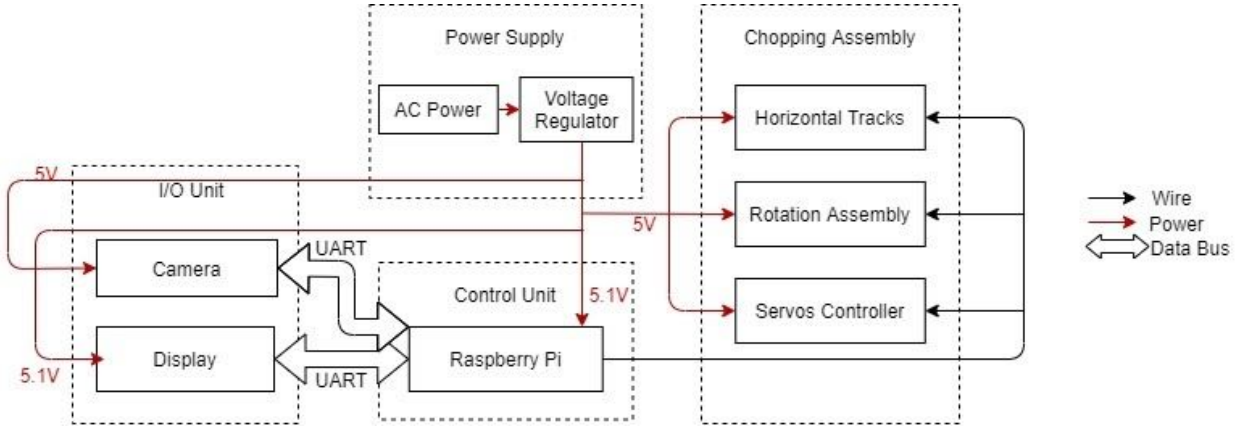

Figure 2. Block Diagram

2.2. Functional Overview

2.2.1 Power Supply

The power supply will draw from a wall outlet and subsequently use voltage regulators to supply the required power to the rest of the different components in the assembly. This supply should be able to supply the varying voltages that are required by the different sub-components in the assembly.

Must supply at least 5.1V at 3A to the pi, 5V to the chopping assembly, 5V to the camera at 2A and 5.1V at 2.5A for the display unit

2.2.2 Control Unit

The Raspberry pi will be the focal point of the project. Using the visual feed from the camera and computer vision, it will recognize the vegetables placed on the chopping board. It will also drive the display unit to accept and confirm user choices. With the information from the initial vegetable detection and user input it will control the chopping assembly. The Raspberry Pi will drive the motors and servos to chop the vegetables in the selected chopping style.

The control unit will interact with the power supply, I/O Unit and the Chopping Assembly. In combination with all these blocks, the control unit will be able to achieve two of the high-level requirements: detecting the type of vegetable placed on the chopping board, and chopping the vegetables with dimensions that are at least 75% accurate in comparison to the standards of french cooking.

Must be able to recognize different types of vegetables, store the chopping instructions for the different chopping styles and then control the motors in the required manner.

2.2.3 Chopping Assembly

The chopping assembly will perform the function of actually chopping the vegetables in accordance with the standards set in French cooking to a 75% degree of accuracy. This assembly will be made of horizontal tracks, a rotating mount on which there will be a linear actuator like the GR9863, attached to two servos like the SG-5010 and parallel clamps that replicate proper chopping techniques.

This assembly must be able to exert a maximum of 300N of force on the vegetables [4], not drawing more than 5V at 3A in total while ensuring that the vegetables are cut within 3 minutes with a 75% accuracy.

2.2.4. I/O Unit

The I/O Unit will comprise the camera and the display unit. The display unit will provide a user interface to the system. The camera and the display unit will provide input to the control unit. The specific purpose and description of the components are provided below.

2.2.4.1. Camera

The camera will be placed inside the casing and will be positioned as shown in *Figure 1*. An ESP32-CAM or a similar kind of camera will work well for this setting. The camera will supply live footage of the object placed on the chopping board to the control unit. This feed will then be used to determine the type of vegetable that has been placed on the board using computer vision.

The camera is crucial to the detection of vegetables, which is one of the high-level requirements for this project. Time permitting, we might also be able to use the camera to ensure the safety of the user by stopping the chopping process if a hand is detected. The camera will only interact with the power supply and the control unit for the scope of this project. Since this is a moonshot we would attempt, we could try to execute on the safety features in other ways too like using an IR field at the edges of the assembly to detect when the users' hands are inside and break the circuit in a more analog fashion!

Must be able to send a visual feed, of the general region where the object to be chopped will be placed, to the Raspberry Pi.

2.2.4.2. Display

The display will display the vegetable that has been detected by the control unit. It will also allow the user to select the chopping style for the vegetable either from the options provided based on the detected vegetable or a different one from the provided chopping styles. It will also have the option to start and stop the chopping process to account for the safety of the user.

The display unit will serve as the primary source of interaction between the rest of the system and the user. The display unit will potentially be a touchscreen display unit. We will be using something like the ER-TFT024-3 display with touchscreen. The display unit will interact only with the control unit and the power supply. The control unit will provide the display unit with the chopping styles that need to be displayed and establish user interaction.

Must display the detected vegetable and allow the user to select the chopping style from a menu. Must also allow the user to start and stop the chopping process.

2.3. Risk Analysis

The chopping assembly will be the greatest risk to complete this project. Since it is highly mechanical, it needs to be very accurate and fulfill the role of successfully mauvering to chop the inserted vegetable. It has multiple moving parts such as the servo to rotate the axis of the knife and move along the horizontal tracks, and lower the unit as a whole towards the object and be able to give enough force to chop up the object. This unit has to work very accurately in order for the control, display, and power unit to work in unison to drive this project to completion.

3. Ethics and Safety

Possible safety concerns of this project contain injuries related to sharp objects. In the ACM Code of Ethics 1.2 [5], we are to “Avoid Harm”. Although we do not plan on providing any blades as of now, as it is meant to be inserted by the user, they 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 to cut their wanted object. We plan to diminish this by making sure the user confirms their choice to chop on the display by an additional button. Considering an even better failsafe, we hope to implement an emergency stop if all else fails and if the user thinks they will hurt themselves accidentally. The consumer should keep away from small children and operate this machine on a flat countertop over the cutting board of their choice that is the appropriate size.

Along with also the issue of safety, this assembly could cause electric shock if mishandled, especially for the environment it is supposed to be used in, 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, but ideally not submerged under water at any point. The consumer might shock themselves if the device is near water or the consumer has an excessive amount of water on their hands to operate it.

References

[1]Smith G. A. (2013). Knife-related injuries treated in United States emergency departments, 1990-2008. The Journal of emergency medicine, 45(3), 315–323. https://doi.org/10.1016/j.jemermed.2012.11.092

[2]https://www.fooddive.com/news/survey-7-in-10-consumers-say-they-will-keep-cooking-at-home-after-the-pand/593532/

[3]https://en.wikipedia.org/wiki/List_of_culinary_knife_cuts

[4] Singh, Vishal & Das, Madhusweta & Das, S.K.. (2016). Effects of knife edge angle and speed on peak force and specific energy when cutting vegetables of diverse texture Cutting force and specific energy for vegetables 23. International journal of food studies. 5. 22-38. 10.7455/ijfs/5.1.2016.a3.

[5]https://www.acm.org/code-of-ethics