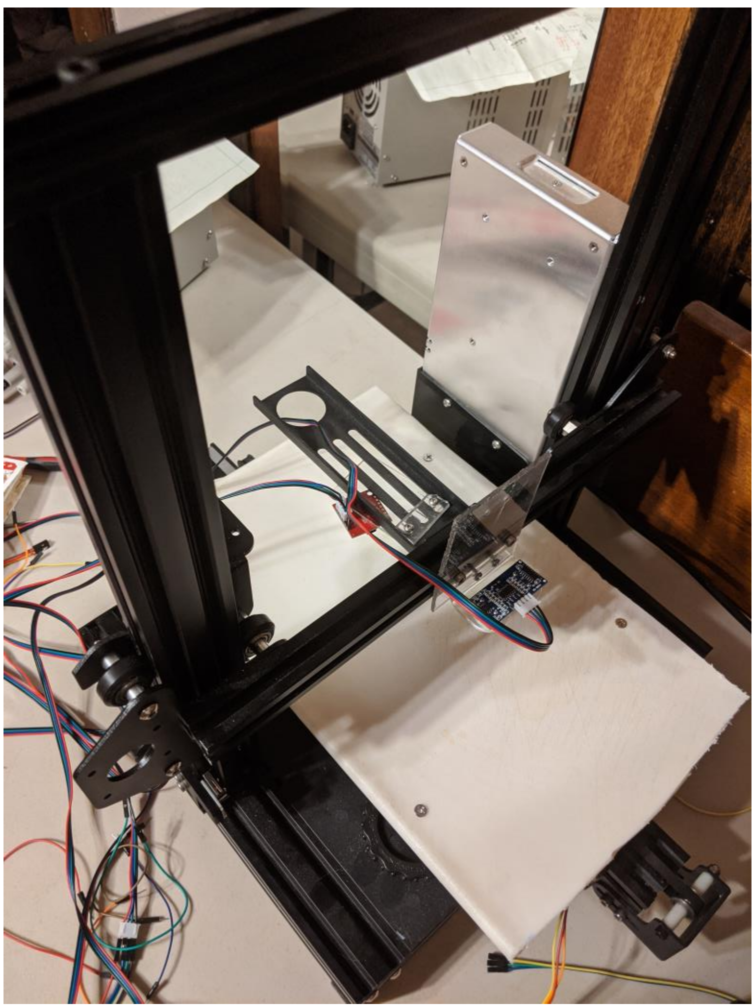
UNIVERSITY OF NEVADA LAS VEGAS
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

EE498 Senior Design
Spring 2020

Project Title

Final Project Report



Group Members:

Name (Print)	CPE/EE/ME
Brian West	CpE
Darryl Derico	CpE
Morgan Kiger	CpE

Instructor: Dr. Grzegorz Chmaj
Faculty advisor:

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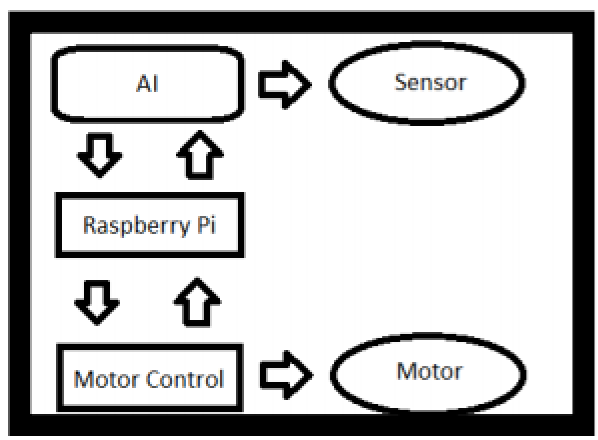
Abstract

The AI Food Quality Sensing System is a tool designed to be used in the home kitchen and commercial kitchen. Determining the current condition of food is impossible for humans and is a subjective process. The purpose of the AI Food Quality Sensing System is to take the guesswork out of telling if food is bad or not and give users peace of mind knowing their food is safe for consumption. To sense the quality of food a multispectral sensor will scan the food and provide data for an AI algorithm to process and determine if the food is good or not. Multispectral sensing has been a huge force in the food industry, but is very expensive in its implementation. The Food Quality Sensing System is going to put this technology in the reach of consumers everywhere. The device is designed with the user in mind. The sensor, computer, and other necessary components will be housed on a base with a small footprint to minimize lost counter space. The machine's decision making will be faster than current market solutions and is far easier to use. The AI Food Quality Sensing System is a breakthrough in taking industry standard technology and placing it in kitchens everywhere.

Introduction & background

The AI Food Quality Sensing System is a project that uses AI and multi-spectral sensors to improve food safety in home kitchens and commercial kitchens. The current goal with the AI Food Quality Sensing System is detecting the difference between safe and unsafe to eat red meat.

The AI Food Quality Sensing System works by having a piece of meat placed on the tray and then moving that piece of meat under the multi-spectral sensor. The sensor takes several readings along the length of the meat and provides the data to AI software. The AI examines the data and determines if the meat is safe to eat or not and displays the determination via LEDs. Once the scan is done, the tray is returned to the original position and the AI Food Quality Sensing System waits for the next start signal.



There is only one other device on the market that performs a similar service. FOODsniffer is a hand held product that specifically scans meats to determine if the meat is fresh. The FOODsniffer must connect to the user's phone to function. The AI Food Quality Sensing System on the hand is a stand-alone system that does not need user interaction while it is scanning the food object and has potential to scan more than just meats.

Current Market Solutions

	Vendor	Footprint	Sensor Type	Stand alone	Price	Comment
FOODsniffer	FOODsniffer	Handheld	Gas	No	130	Small,cheap, works with meats only
Your dev.	AI Food Quality Sensing System	Countertop	Multi-spectral	Yes	~200	Larger, can potentially work with different types of food, more expensive

Table 1. Comparison of available devices

	Resolution	Battery life	Price	Stand alone	Strengths	Weaknesses
FOODsniffer	High	Long	Medium	No	▪ High resolution ▪ Long battery life	▪ High price, hand held
AI Food Quality Sensing System	Low	None	High/Medium	Yes	▪ No battery, stand alone	▪ Low resolution

Table 2. Strengths and weaknesses of available devices

Research results

In working with this project, we learned that the sensors we are using lacks the resolution needed to get the results we wanted. The primary goal of the project was to accurately detect when a piece of meat goes from good to bad. Unfortunately, the sensor lacked the resolution to do this and instead was only able to distinguish between good meat and meat that had been bad for a while.

The other issue we encountered, but did not have enough time to troubleshoot was the Y axis motor. Our project included the ability to move the height of the multi-spectral sensor to always be a fixed height above the piece of meat. In testing this worked, but once fully assembled the motor had a lot of trouble with moving the assembly. The most likely reason is the motor driver is not pulling enough current.

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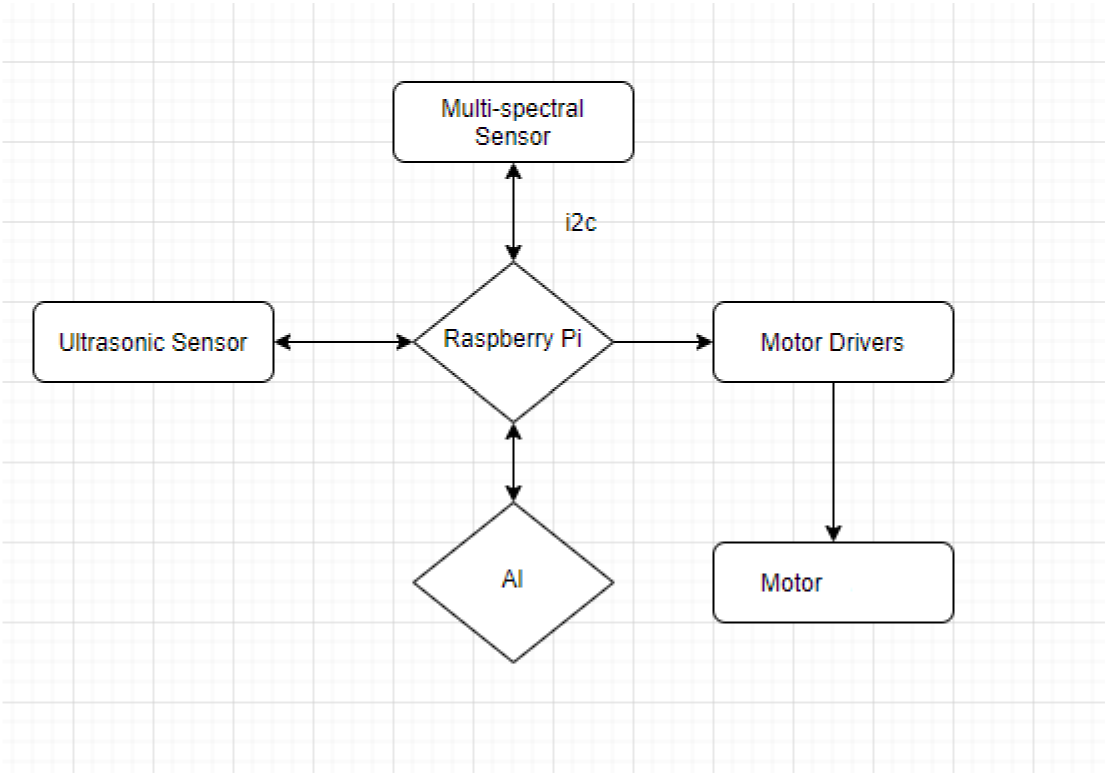
Specification of the project

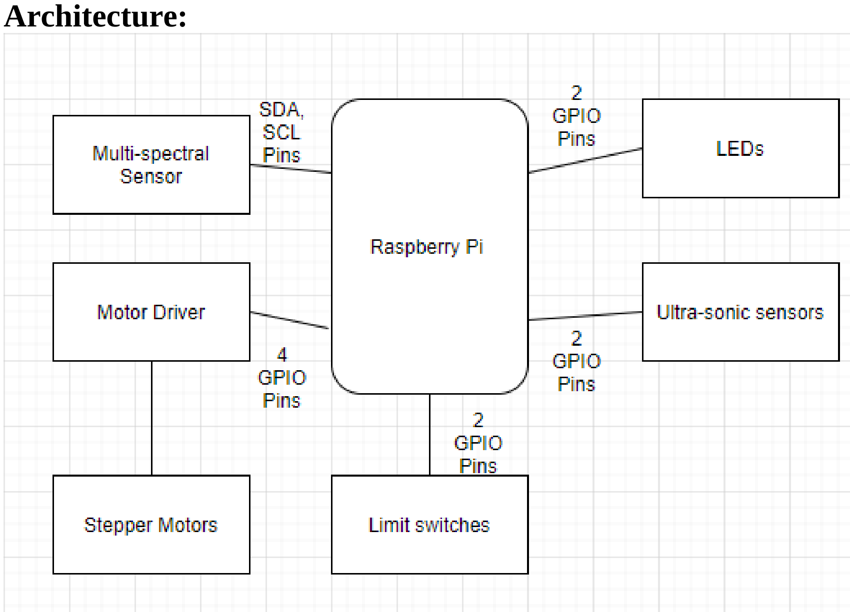
Functionality & conceptual design:

The device works by the user placing a piece of meat on the tray and pressing the start button. Once the button is pressed the Raspberry Pi starts sending step signals to the X motor until the ultrasonic sensor detects a change in height. Once the change in height is detected, the X motor steps a specific number of steps to get the piece of meat under the multi-spectral sensor.

Then the Raspberry Pi resumes stepping the X motor and sends signals back and forth between the multispectral sensor over i2c.



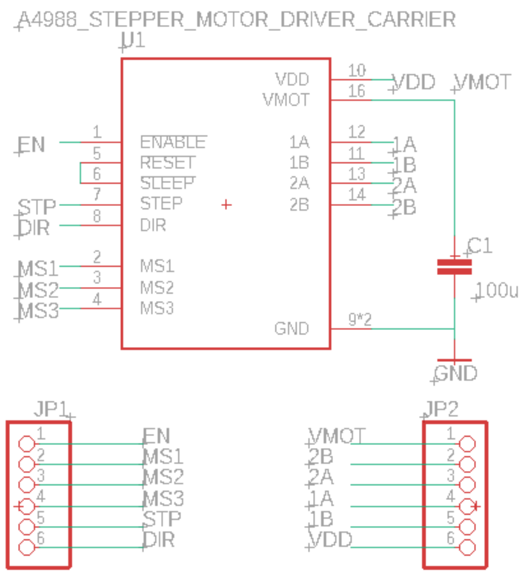
Architecture:



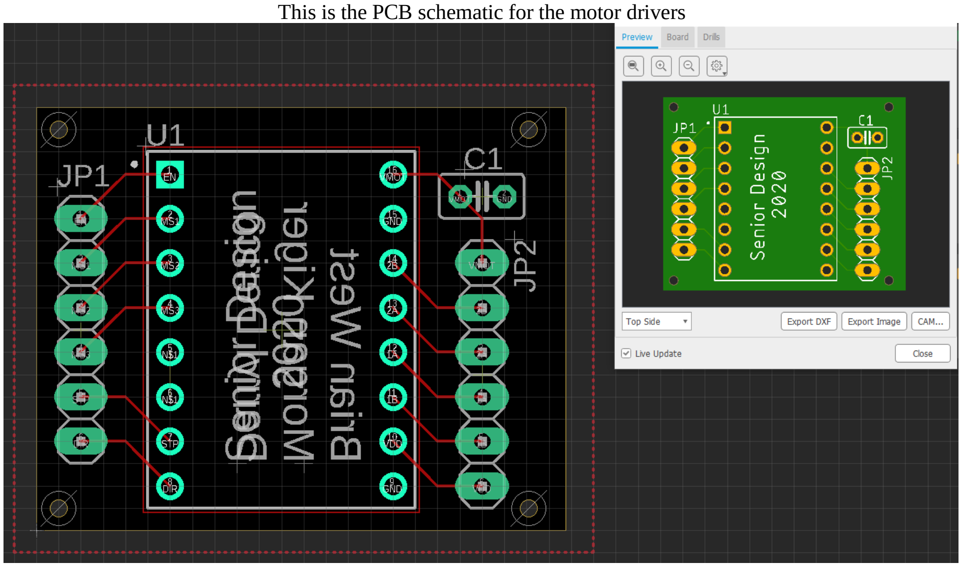
Physical Architecture with pin connections.

Module	Input	Output	Operation
Raspberry Pi	-Echo ultrasonic sensor - Multi-spectral Data(i2c) - Limit Switch signals	-Trigger ultrasonic sensor -Motor Step signals -Motor Direction signals -Multi-spectral sensor signals (i2c) -LED signals	The Raspberry Pi's operation is to be the brains of the system. It sends and receives signals to scan the meat and contains the AI that makes the decision about the meat.
Multi-spectral Sensor	- Multi-spectral sensor signals (i2c)	-Multi-spectral data	Scans the meat and passes data over to the Raspberry Pi
Ultrasonic Sensor	-Trigger	-Echo	Determines height from sensor assembly to piece of meat to ensure consistent height of sensor over meat.
Motor Driver	-Motor step signals -Motor dir signals	-Motor steps	Allows the Raspberry Pi to control the direction and the steps of the stepper motors with only 2 pins.
Motor	-Motor steps		Moves tray and sensor assembly to scan meat
LEDs	-LED signals		The signals received from the Raspberry Pi show the user whether the piece of meat is good or bad.
Limit Switches	-Mechanical movement	-Limit switch signals	The limit switches tell the Raspberry Pi where "home" is for the stepper motors. This is primary used to reset the machine after a scan is completed.

Design



This is the PCB schematic for the motor drivers



Testing

In order to test the full functionality of the system, place a piece of meat on the tray and press start. The machine will move the meat under the sensor, collect data, make a determination, then put the tray back in the original position. To ensure the system is working as intended scan with a good piece of meat and a bad piece of meat.

Multi-spectral Sensor Test

In order to test the function of the Multi-spectral sensor we wrote the software interface and created a temporary assembly that could adjust the height of the sensor above a piece of meat. This test was mainly to test that the software we wrote to implement the i2c worked with the Raspberry Pi and the sensor. This assembly was the main way we collected training data while we finished getting and assembling the full frame.

Motor Test

To test the stepper motors the circuit with the motor drivers, motors, and Raspberry Pi was built and the ultrasonic sensor was added once the basic circuit was tested and working to test the ability of keeping a consistent height. The test worked with the ultrasonic sensor as it was hooked up to the X axis part of the frame. The Y axis test did not work.

User's manual

Setup

1) Plug in machine
2) Wait ~30 seconds to let the machine bootup.

How to use

1) Place piece of meat on tray.
2) Press start button
3) Wait for scan to finish
4) If the yellow LED lights up the meat is good to eat, if the red LED lights up the meat is not safe to eat.
5) Remove piece of meat once the tray reaches the original position.
6) Repeat

Roles & skills in the project

	Objects involved	**Required skills**
Motor Control Unit Design	Motor drivers, stepper motors, Raspberry Pi, ultrasonic sensor.	Understanding stepper motors and PWM.
PCB	Motor driver	CAD
AI	Raspberry Pi	Python, Machine Learning, Data Processing
Multi-spectral Sensor	Raspberry Pi, Multi-spectral sensor	Python, i2c

Table 3. Roles & skills

	Assignment
Motor Control Unit Design	Brian West
PCB	Darryl Derico
AI	Morgan Kiger
Multi-spectral Sensor	Brian West

Table 4. Roles assignment

Parts list

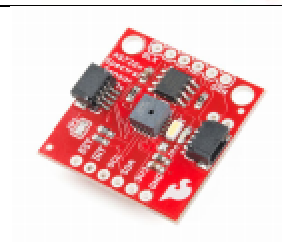
	Parameters	Picture	Att. id
Stepper Motor	1.5A 1,8 degrees		
Stepper Motor Driver	8V to 35V, adjustable current limit		
Raspberry Pi 4	4GB Ram, quad-core Cortex-A72		
Multi-Spectral Sensor	NIR bands		
Ultra-Sonic Sensor	3mm resolution		

Table 5. List of required parts

Project timeline

November 2019 – Software interface for multispectral sensor completed and training data collection begins
December 2019 – Circuit schematic design and breadboard test is completed. Issues with resolution of sensor discovered.
January 2020 – New sensor is being tested (issues with software interface)
February 2020 – PCB design begins (Learning how to use the CAD software)
March 2020 – Frame assembly begins (issues with fitting components on frame)
April 2020 – New sensor is put to the side, return to old sensor

- The new sensor was having issues propagating data from all three sensors in time to get multiple data points. (Motors were moving faster than the sensor could scan).

May 2020 – Frame assembly is completed and additions to motor control unit(issues with the Y axis motor, unable to determine cause).

Final remarks

The three of us in this group thoroughly enjoyed working on this project. From motor control, AI, and PCB work the three of us each got to work in an area that was of interest to us and challenging. This project was by far one of the most challenging projects we have worked on because of the amount of research and testing that went into it.

We would like to thank Dr. Greg for the project idea and his patience with us throughout this process. We would like to thank Dr. Venki for his help and advice on parts selection. A huge thank you to Smith’s Grocery Store for not kicking Brian out for buying as much meat as he did to get testing data.

Marketing flyer

Prepare the marketing flyer – at least 2 pages (so it could be printed both-sides). Include buzzwords, key functions, large, good quality and good looking pictures. Use only layman’s words in this section. Start marketing flyer at the top of new page. This flyer can be later used during the Senior Design competition day – you would just have to print it.

Consider this template as a guideline, not as a form that you fill. Each of elements above must be included (if applicable), but I encourage you to extend this with anything that you consider worth to place in this report. Don't send the report with just tables filled and few sentences of description. This report needs to be a comprehensive description of what you have done during the semester and as complete as possible manufacturing/technical manual describing your device.

Include all the information that you submitted in progress reports or any previously submitted documents.
Combine all the documents (diagrams, attachments etc) into one single PDF file.

The final report is the maximum comprehensive description of your project – include everything about it. Include all technical details.

Remember to name your file using the following syntax:

LastnameLastname-Project_topic.docx

(Acceptable file formats: doc, docx, pdf).

Remove all text in green.